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United States Circuit Court,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY
v.
AMOS E. DOLBEAR ET AL.

COMPLAINANTS' MOVING PAPERS ON MOTION FOR PRELIMINARY INJUNCTION.

CHAUNCEY SMITH,
JAMES J. STORROW, } *for Complainants.*

BOSTON:
ALFRED MUDGE & SON, LAW PRINTERS, 34 SCHOOL STREET.
1882.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY

No. 1628.

AMERICAN BELL TELEPHONE COMPANY
v.
AMOS E. DOLBEAR ET AL.

BILL OF COMPLAINT.

[FILED OCT. 10, 1881.]

To the Honorable the Justices of the Circuit Court of the United States for the District of Massachusetts:

The American Bell Telephone Company, a corporation duly established under the laws of the Commonwealth of Massachusetts, brings this its bill of complaint against Amos E. Dolbear, of the city of Somerville, State of Massachusetts; Francis M. Holmes, of the city of Boston, State of Massachusetts; and Henry B. Metcalf, of the city of Pawtucket, State of Rhode Island.

And thereupon your orator complains and says: —

1. That before the seventh day of March, 1876, Alexander Graham Bell, then of Salem, in said Commonwealth, being the original and first inventor of a new and useful improvement in telegraphy, which was never known or used before his invention thereof, and which had not at the time of his application been in public use or on sale for more than two years, made application according to law for Letters Patent of the United States to be granted to him therefor; upon which application, due proceedings being had in all respects, said Letters Patent were on the seventh day of March, 1876, granted, issued and delivered to said Alexander Graham Bell, signed

by the Secretary of the Interior and countersigned by the Commissioner of Patents, and numbered 174,465, whereby there was secured to said Alexander Graham Bell, his heirs, administrators or assigns, for the term of seventeen years from the said seventh day of March, 1876, the full and exclusive right and liberty of making, constructing, using and vending to others to be used the said improvement, a description whereof is given in the words of the said Bell, in the schedule annexed to said patent, and forming a part thereof, as by said patent, numbered 174,465, or a copy thereof, here in Court to be produced, will fully appear.

2. Before the thirtieth day of January, 1877, the said Alexander Graham Bell, being the original and first inventor of another new and useful improvement in electric telegraphy, which was never known or used before his invention thereof, and which had not at the time of his application been in public use or on sale for more than two years, made application according to law for Letters Patent of the United States to be granted to him therefor; upon which application, due proceedings being had in all respects, said Letters Patent were, on said thirtieth day of January, 1877, granted, issued and delivered unto said Bell, signed by the Secretary of the Interior and countersigned by the Commissioner of Patents, and numbered 186,787, whereby there was secured to said Bell, his heirs, administrators or assigns, for the term of seventeen years from the said thirtieth day of January, 1877, the full and exclusive right and liberty of making, constructing, using and vending to others to be used the said improvement, the description whereof is given in the words of said Bell in the schedule annexed to said last-named patent, and forming a part thereof, as by said patent, numbered 186,787, or a copy thereof, here in Court to be produced, will fully appear.

3. Said Alexander Graham Bell assigned said Letters Patent, numbered respectively 174,465 and 186,787, to Gardiner G. Hubbard, trustee, by deed of assignment dated July 9, 1877, and recorded at the Patent Office, July 28, 1877, Liber R^{22}, page 399 of Transfers of Patents. That said Gardiner G. Hubbard, trustee, assigned said Letters Patent, numbered respectively 174,465 and 186,787, to the Bell Telephone Company, by assign-

ment dated July 20, 1878, and recorded at the Patent Office, Oct. 3, 1878, Liber Y^{22}, page 460 of Transfers of Patents.

4. Said Bell Telephone Company has granted the same to your orator, the American Bell Telephone Company, by an instrument in writing, dated June 22, 1880, and recorded at the Patent Office, June 24, 1880, Liber I^{25}, page 282 of Transfers of Patents.

5. The sole right to manufacture electric speaking telephones under said patents thereby became and still is vested in the said American Bell Telephone Company; that the only right granted to or possessed by any persons other than the said American Bell Telephone Company under said patents has been and is the right to use telephones procured from said American Bell Telephone Company and its predecessors, upon payment of stated royalties under said two patents to the said American Bell Telephone Company.

6. Electric speaking telephones had never been publicly known or used before the grant of said patent, and were first publicly made known and first introduced into public use by said Bell and his licensees under said Bell patent; and but for the unlawful acts of the defendants hereinafter complained of, your orator would be in the full and exclusive enjoyment of said rights.

7. Your orator further shows, that after the grant of said Letters Patent, the inventions therein described and claimed, or substantial and material parts of the same, embodied in instruments known as Bell telephones, and in instruments known as Blake transmitters, were before July, 1877, and January, 1879, respectively introduced into general public use by the said Bell, the said Hubbard, trustee, the said Bell Telephone Company and your orator. That many thousands of persons have put the said inventions into daily use under the authority and license of the said Hubbard and your orator, and its predecessors, and those holding rights or licenses under them, and have paid for such use of said inventions the amount fixed by the owners of said patents as a reasonable compensation therefor, such payments amounting in the aggregate to many thousands of dollars. That telephone exchanges now exist in more than five hundred towns and cities of the United States, and in every State thereof, and exist in substantially every city of the

Wm H. Fisher 4-3-82

United States having more than 15,000 inhabitants, and in many smaller places; and all said exchanges use telephones licensed by your orator, the American Bell Telephone Company, and its predecessors, as owners of said Bell patents, and pay royalty therefor to your said orator. That the fact that said Bell was the original and first inventor of said inventions, and that the patents above named are good and valid patents, has been generally recognized and acknowledged by those who have used the inventions and the public generally, in all parts of the United States, and the claims of the said Bell, Hubbard and your orator and its said predecessors, to the exclusive right to the said inventions under said patents have been generally acknowledged and acquiesced in. That from time to time several persons have attempted to make, sell and use telephones, or parts thereof, embracing said inventions, but that in such cases said Hubbard while owner of, and your orator and its said predecessors since they have owned said patents, have immediately upon hearing of such acts or attempts notified such parties to desist therefrom, and that such parties have generally, upon receiving such notices, complied therewith, and acquiesced in and recognized as valid the claims of said Hubbard and your orator under said patents; and said Bell, said Hubbard and your orator have always asserted and maintained, and but for the wrongful acts of the defendants would and have hitherto almost universally enjoyed the sole and exclusive right to practise said inventions; that they have not acquiesced in any infringement of their exclusive rights; that no persons or parties except your orator, the American Bell Telephone Company, and its licensees are now openly engaged in the manufacture or use of electric speaking telephones, save and excepting the defendants and possibly a few small infringers whom your orator is about to proceed against; and that the said exclusive rights of your orator are of great value to it.

8. There are now in use more than 160,000 electric speaking telephones licensed by and paying royalty to your orator, the American Bell Telephone Company; that the owners of said Bell patents, and those who now are or heretofore have been licensed by them, have devoted great time and attention and large sums of money to the development of the telephone and the introduction thereof into

extensive use, and to the proper construction of the most suitable telephone lines and systems and telephonic appliances, and have constructed many thousand miles of telephone lines for use with telephones owned by your orator, the American Bell Telephone Company, and licensed by it for such use; and that nothing which the defendants or either of them have done has contributed in any substantial way to the development of the telephone, or the introduction thereof into use.

9. From time to time sundry persons have undertaken to manufacture and use electric speaking telephones, and to infringe the said patents; that the owners of said patents have required them to stop, and for the most part they have, upon being so notified, desisted from such infringement; that your orator, the American Bell Telephone Company, and its predecessors, owners of said Bell patents, have brought suit in the courts of the United States and obtained injunctions and decrees against such infringers; and among the suits so brought and which have resulted in injunctions or decrees are the following: —

10. The said exclusive rights of said Bell, and your orator, the American Bell Telephone Company, and its predecessors, as his assigns and grantees, have never been openly or publicly violated, to any considerable extent, except at one time and in the year 1878, by the Western Union Telegraph Company, and by the Gold and Stock Telegraph Company, and by the American Speaking Telephone Company, said three corporations having associated themselves together for that purpose; that said Bell Telephone Company brought its bill in equity in the Circuit Court of the United States for the District of Massachusetts, against Peter A. Dowd, an agent of said associated companies, engaged in the business of using their infringing telephones, and in said suit complained of the defendant that he had infringed the fifth claim of said patent 174,465; and also complained that he had infringed the third, sixth, seventh and eighth claims of said patent 186,787; the said associated corporations assumed the defence of said suit, and employed in said defence their counsel and experts learned in the law and skilled in the art; in said suit evidence was taken and completed by the complainants

in chief, and by the defendant in defence, and by the complainants in reply; and thereupon, upon consideration of said proof, and the opinions of their professional advisers, the defendant and said corporations became satisfied that said Bell was the true, original and first inventor of the electric speaking telephone, and the inventions covered by said patents; whereupon they submitted to the said claims of the complainants, and agreed to desist from further infringements, and have since desisted from further infringements, and placed and caused to be placed all telephones within their power or control under license under said Bell patents, and paid or caused to be paid the usual and customary yearly royalties therefor habitually charged by the assigns of said Bell to other parties for like uses, and agreed that they would not thereafter make electric speaking telephones, and would not thereafter use electric speaking telephones, except such as should be made and furnished to them by your orator or the assigns of said Bell, and under license under said Bell patents, and that for the use of the same they should pay not less than the usual and accustomed royalties from time to time charged to others by your orator; and in accordance with the said advice of counsel of said telegraph companies a final decree was thereafter made and entered in said suit for the complainant, with the consent of the defendant Dowd, and in and by said decree the said two Bell patents were adjudged and declared to be valid patents, and the defendant was perpetually enjoined from infringing the same.

11. In the year 1880 the People's Telephone Company, a corporation organized under the laws of the State of New York, and Frank A. Klemm, Joseph Loth, Julius Bien, Marcus Marx, Auguste H. Girard, John N. Goodwin, Ernest Marx, Edgar W. Chellis, Richard C. McCormick, Henry D. Cooke, Jr., Max L. Gutman, Moritz Loth and Simon Wolf, did make, sell and use, and threaten to make, sell and use certain electric speaking telephones, some of which were known as the "Klemm" telephones, and some of which were known as the "Tisdel" telephones; that said defendants owned the alleged inventions of Frank A. Klemm and of Abner G. Tisdel, and of Daniel Drawbaugh, relating to electric speaking telephones; that thereupon your orator, the American Bell

Telephone Company, and the Metropolitan Telephone and Telegraph Company, a licensee of said American Bell Telephone Company, did, in the Circuit Court of the United States for the Southern District of New York, file a bill in equity against all of said parties, complaining that such acts done and threatened infringed the rights secured to the said orators by the said two Bell patents, 174,465 and 186,787; and did also move for an injunction thereon *pendente lite.* Said motion came on to be heard in said Court before the Hon. Samuel Blatchford, circuit judge, on the nineteenth day of November, 1880, on affidavits and proofs filed by the respective parties, and was argued by counsel, to wit, Chauncey Smith and James J. Storrow, Esquires, for the complainants, and by George Harding, Esq., for the defendants; upon consideration whereof the Court did order an injunction as prayed for, restraining the defendants from infringing the said two patents of your orator, numbered 174,465 and 186,787; that such injunction issued accordingly on the twenty-second day of November, 1880; and your orator refers to a copy of the record in said suit, to be produced, and prays that the same may be made part hereof.

12. In the year 1880, the Eaton Telephone Company and its associates did infringe said patents in New York, by making and selling an electric speaking telephone apparatus, composed of a magneto telephonic receiver of a form and style called by them the "Eaton Magneto Telephone," and of a microphone battery telephonic transmitter, with carbon contacts; and did infringe said Bell patents in Massachusetts, by selling the same to others by their employé, Albert L. Spencer; whereupon your orator, the American Bell Telephone Company, brought suit against said Eaton Telephone Company and others in the United States Circuit Court in the city of New York, and against said Spencer in Boston, complaining that said defendants had hereby infringed Claim 5 of Patent 174,465, and Claims 5, 6, 8, of Patent 186,787; and said Eaton Telephone Company and their associates defended said two suits, and employed in that behalf counsel learned in the law and experts: whereupon a preliminary injunction was issued in both suits. Afterwards said suits were prepared for final hearing, and the defendants denied the validity of said patents, and denied that the use of a microphone

telephonic transmitter with carbon contacts infringed said patents; and in support of such denial and of other allegations in their answer, they introduced evidence; and among other evidence they introduced the depositions of Elisha Gray and of William M. Goodridge and of Henry Morton and of Edward S. Renwick; and the same evidence on both sides was introduced in said two suits. Said suit in Boston came on to be heard on final hearing before his Honor Judge Lowell, circuit judge at Boston, and was argued by counsel, and was, on June 27, 1881, decided by the Court in favor of the complainants; and in its said decision the Court, among other things, expressly held and decided that all the said claims of said patents sued on were good and valid claims, and that said patents were valid patents, and that the use of the kind of speaking-telephone transmitter commonly known as a microphone transmitter with carbon contacts, whereby the resistance of a battery circuit was varied by variations of pressure, due to vibrations imparted to one electrode by sound waves, infringed said fifth claim of the Bell patent 174,465. Your orator craves leave to refer to the record of said case, and to the opinion of said Court therein pronounced, and that the same may be made and deemed to be part hereof.

Also the following: —

13. A suit in the United States Circuit Court in Boston, brought in 1878 against Addison D. Hard, electrician, which resulted in a preliminary injunction; afterwards the said defendant made and exposed for sale some parts of electric speaking telephones, to the end that the purchasers thereof should complete and use the same; whereupon, after hearing, he was adjudged guilty of contempt and ordered to pay a sum of money into court, which sum was afterwards ordered to be paid and was paid to the complainant, the Bell Telephone Company. Said suit has been terminated by a final decree for the complainants.

14. A suit in the same court against Jerome C. Redding, electrician, in 1878, which resulted in a preliminary injunction and a final decree for the complainants.

15. A suit in 1878, in the United States Circuit Court in New York, against Jesse H. Bunnell, manufacturing electrician, who

appeared by counsel, and resulted in an injunction and a final decree for the complainants.

16. A suit in 1878 against Charles E. & W. H. Jones, in the United States Circuit Court in Cincinnati, wherein said defendants appeared by counsel, and in which a final decree declaring the validity of said patents, and enjoining further infringement thereof, was issued against them.

17. A suit in 1880, in the United States Circuit Court in New York, against Pearce & Jones, manufacturing electricians, in which said defendants appeared by counsel, but which resulted in a final decree declaring the validity of said patents, and enjoining further infringement thereof.

18. A suit in 1880, in the same court, against J. L. Lazelle, a manufacturer of electrical apparatus, complaining that he infringed said patents by making and selling a form of magneto telephones sometimes called "Lazelle" telephones, and a form of microphone telephonic transmitters, sometimes called the "Little Gem" tran-mitters; and said suit resulted in a preliminary injunction, and a final decree and perpetual injunction.

19. A suit in 1881, in the United States Circuit Court in Chicago, against Edward E. Harbert and Harbert & Co., manufacturing electricians, in which said Harbert appeared in person and a hearing was had, which resulted in a preliminary injunction, and a final decree and perpetual injunction.

20. A suit in 1881, in the same court, against the Foster Magnet Telephone Company, Gay W. Foster and others, in which the defendants appeared by counsel, and which resulted in a preliminary injunction, and a final decree establishing the validity of said patents and perpetually enjoining all further infringement thereof.

21. All said injunctions and decrees still remain in full force and effect, and all said named defendants have, so far as the complainant is informed, entirely ceased to use or sell electric speaking telephones.

22. And your orator shows that the telephones made by your said orator and the infringing telephones of the defendants are small instruments, and easily concealed, and easily used in private, and

easily transferred from one person to another, so that it is generally extremely difficult for your orator to detect all instances of such use, and extremely difficult to prove the use thereof by persons not licensed by your orator, and the extent of such use, and would be extremely onerous and burdensome for your orator to bring separate suits against each user to restrain said infringing use; and so, if the defendants, or either of them, shall be allowed to continue to manufacture and supply such instruments for use during the pendency of this suit, your orator will be wholly without adequate remedy in the premises.

23. Yet the defendants, well knowing the premises and the exclusive rights of your orator as aforesaid, but contriving to injure your orator and to deprive it of the benefit and advantage which might and otherwise would accrue to it from said inventions, without the license or consent of your orator and in infringement of the said patents, have, as your orator is informed and believes, jointly made, sold and used telephones embracing the inventions secured to your orator in said Letters Patent, or substantial and material parts of them, and have used the several improvements secured to your orator by said patents, and are still using the said several improvements at Boston and divers other places within said district, and have furnished electric speaking telephones made by them to a considerable number of persons within this district, to be connected up and used as electric speaking telephones for the transmission of articulate speech, by and according to the method secured to said Bell and to your orator by said patents, and still continue so to do; but precisely how long the defendants have made, sold and used the said several improvements, and to what extent they have made, sold and used them, your orator, for want of a discovery thereof, does not know and cannot set forth, and it prays that the defendants may be compelled to set forth the same in their answer.

And your orators have been informed and have good reason to believe and do believe as follows: Said Dolbear has constructed an electric speaking telephone apparatus, one station of which he has placed upon his own premises, 70 Washington Street, Boston, and the other station of which he has placed at the furniture warehouse of the defendant Holmes, 107 Washington Street, Boston, and still maintains and uses the same, and he and his associates have on more than one occasion during the past three months publicly asserted and represented that they have the right to make, use and sell such instruments; and they have on more than one occasion during the past three months publicly asserted and represented that they intend to do so, and that in order the better to provide means and facilities for doing so on a large scale and extensively, they intend to organize a corporation for that purpose; that said speaking-telephone line and apparatus were by the defendants publicly exhibited to and used by large numbers of persons, partly with intent to induce such persons to become stockholders in such proposed corporation and users of similar telephones to be furnished by said defendants, and in order to aid in and promote the extensive use of such instruments; and that said assertions and representations have very recently been repeated by the defendants, and your orator verily believes that unless restrained by order of this honorable Court, the said defendants, or some of them, will at once perform some of the infringing acts which they so threaten and intend, and will perform them to such an extent as to cause great and irreparable damage to your orator.

24. Your orator has requested the said defendants to acknowledge its rights in the premises, and to desist and refrain from the said acts, and from disregarding and infringing your orator's said rights, and to account with and pay to your orator what is justly due to your orator by reason of said infringement.

25. But now so it is, may it please your Honors, that the defendants wholly refuse so to do; but on the contrary, continue and threaten to continue said infringement of the rights of your orator aforesaid, and particularly threaten to make and put out other like instruments, and thereby cause irreparable injury to your orator's lawful business: all which is contrary to equity and good conscience.

26. To the end, therefore, that the said defendants may, if they can, show why your orator should not have the relief herein prayed, and may upon their oaths, and according to their best and utmost knowledge, remembrance, information or belief, full, true, direct and perfect answer make to all and singular the matters hereinbefore stated and charged, as fully and particularly as if the same were

here repeated, and they especially interrogated as to each and every of said matters: and more especially may answer, discover and set forth, whether during any and what period of time, and whether at said Boston or elsewhere, and when and where, they used said improvements, or either of them; and whether they manufactured or sold any electric speaking telephones or apparatus to transmit speech by electricity, or the various parts of such telephones, and how many they have made or sold, and to whom they have sold the same, and how the said telephone and the several parts of the same are constructed and used; and particularly shall state whether or not they have declared and represented that they intended to furnish or cause to be furnished such telephones for use by others, and whether they have represented and declared that they intended to get up and organize a corporation for that purpose.

27. And your orator shows that it is entitled to restrain all further use of telephones which have been or shall be manufactured and disposed of by the defendants or either of them, and to receive and collect from each user thereof a suitable sum as and for damages and profits in consequence of and growing out of such use by each person who has used the same; and not waiving said rights, but wholly insisting thereon, and asserting that it intends to pursue and enforce said rights against said users, your orator avers that the defendants are also liable to pay to your orator other sums as and for profits by them actually realized by and from said infringement and unlawful acts. Wherefore your orator prays that the defendants may be decreed to account for and pay over to your orator all such gains and profits resulting to them from said infringements; and may be restrained, together with their servants and agents, by an injunction to be issued out of this honorable Court, or by one of your Honors, according to the law in such case provided, from making, selling or using the said improvements, patented as aforesaid, or either of them; and that they may also be enjoined and restrained as aforesaid during the pendency of this suit, and for such other and further relief in the premises as the nature of the case may require and to your Honors shall seem meet.

28. May it please your Honors to grant unto your orator, not only a writ of injunction, but also a writ of subpœna, to be directed

to the said defendants, and each of them, commanding them and each of them, at a certain time and under a certain penalty therein to be limited, personally to be and appear before your Honors and this honorable Court, then and there to answer unto this bill of complaint, and to do and receive what to your Honors shall seem meet in the premises.

THE AMERICAN BELL TELEPHONE COMPANY,
By THEO. N. VAIL,
General Manager.

JAMES J. STORROW,
Solicitor and of Counsel.

UNITED STATES OF AMERICA,
STATE OF MASSACHUSETTS, } SS.
SUFFOLK COUNTY,

OCTOBER 20, 1881.

Personally appeared Theo. N. Vail, above named, and having been duly sworn, doth depose and say that he is general manager of said American Bell Telephone Company, and of said Bell Telephone Company; that he has read the foregoing bill and knows the contents thereof; that all the matters therein stated as to the acts of said two corporations he knows to be true; that all other matters therein stated he believes to be true; and believes the said Bell to be the true, first and original inventor of the improvements in said two patents set forth and claimed; and that the same had not been in public use or on sale two years before his respective applications for said two patents.

Sworn to before me,

[SEAL]

GEO. WILLIS PIERCE,
Notary Public.

2 Sheets—Sheet 1.

A. G. BELL.

TELEGRAPHY.

No. 174,465.   Patented March 7, 1876

Fig. 1.

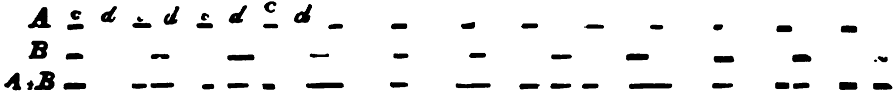


Fig. 2.

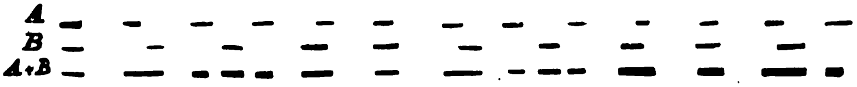


Fig. 3

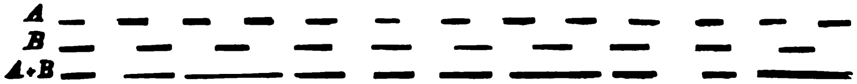


Fig. 4.

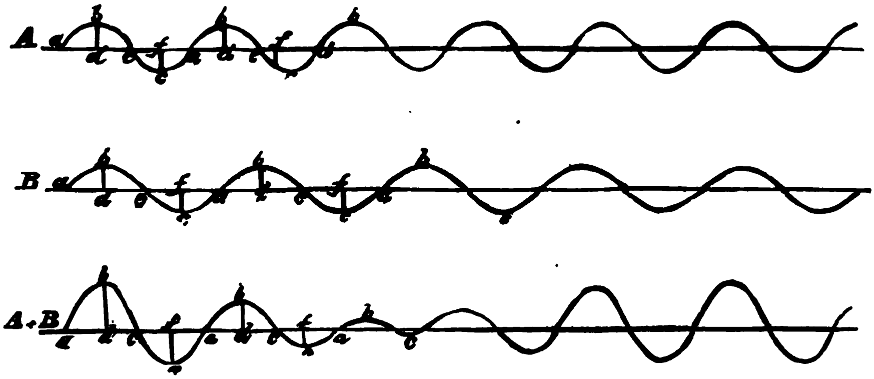
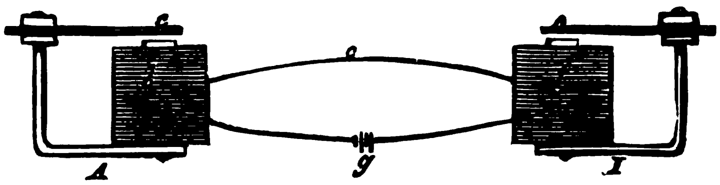


Fig. 5.



Witnesses:

Ewell A. Dick
H. J. Hutchinson

Inventor:

A. Graham Bell
by atty Pollok & Bailey

2 Sheets—Sheet 2

A. G. BELL.

TELEGRAPHY

No. 174,465.

Patented March 7, 1876

Fig. 6.

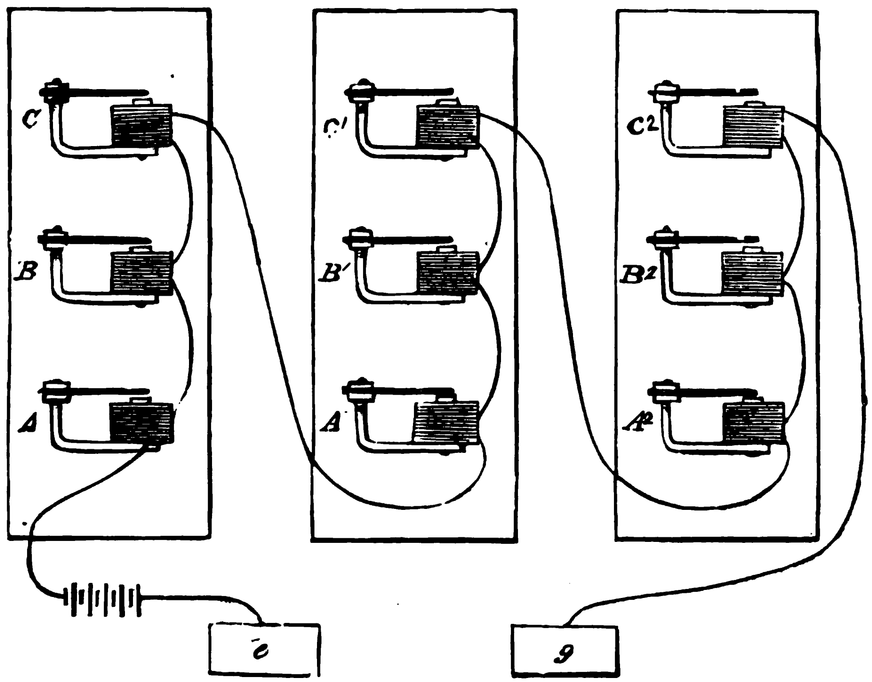
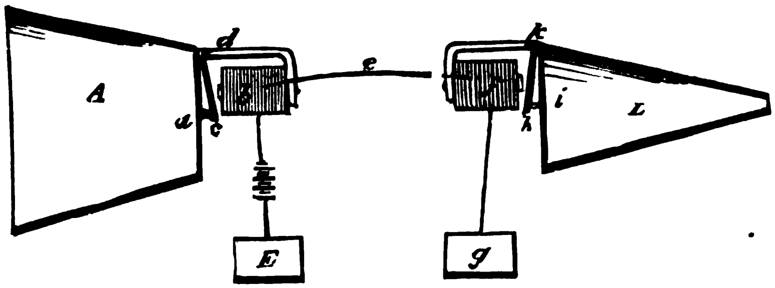


Fig. 7



Witnesses:

Ewell A. Dick,

H. J. Hutchinson

Inventor:

A. Graham Bell

by atty Pollok & Bailey

UNITED STATES PATENT OFFICE.

Alexander Graham Bell, of Salem, Massachusetts.

IMPROVEMENT IN TELEGRAPHY.

Specification forming part of Letters Patent No. 174,465; dated March 7, 1876, application filed February 14, 1876.

To all whom it may concern:

Be it known that I, Alexander Graham Bell, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:

In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving-instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register, or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy, I have shown in the patent aforesaid, as one form of transmitting-instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan, the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when a number of transmitting-instruments having different rates of vibration are simultaneously making and breaking the same circuit, the effect upon the main line is practically equivalent to one continuous current.

In a pending application for Letters Patent, filed in the United States Patent Office, Feb. 25, 1875, I have described two ways of producing the intermittent current — the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a "pulsatory current."

My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line-wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity, exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction-coils; fourth, that cable-despatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use, for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter, and that when it is made to recede, a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

That the difference between an undulatory and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously — first upon the one plan, and then upon the other. Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used, the circuit is made and broken four times by one transmitting-instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2, and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, &c., show where and for how long time the circuit is made, and *d d d*, &c., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting-instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2, and in Fig 3 the makes and breaks are of equal duration. The combined effect, A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting-instruments of different rates of vibration are simultaneously making and breaking the same circuit the current upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; or, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body — that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration — that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body — that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinuosoidal curve A or B, Fig. 4, represents graphically the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c., indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5 — that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A×B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A×B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar-magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting-wire is immersed in the mercury or other liquid the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting-wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed, produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet. A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current;

but the moment it is set in vibration to produce its musical note, a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f*, causes vibration in its armature *h*, when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration, remain silent. Thus if A, Fig. 6, is set in vibration, the armatures of A^1 and A^2 will vibrate also, but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note the instruments B B^2 respond. They continue sounding so long as the mechanical vibration of B^1 is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound. When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting-instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by A^1 and A^2, but by no other instrument upon the circuit; the signals of B^2 by B and B^1, and the signals of C^1 by C and C^2 — whether A, B^2, and C^1 are successively or simultaneously caused to vibrate. Hence, by these instruments, two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *c*, Fig. 5, is set in vibration, the armature *h* responds not only in pitch but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly, the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously (A loudly and B softly,) the instruments, A^1 and A^2, repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration," and "undulation" are used synonymously, and in contradistinction to the terms "intermittent" and "pulsatory." By the term "body capable of inductive action," I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action brass, copper, and other metals, as well as iron and steel.

Having described my invention, what I claim and desire to secure by Letters Patent, is as follows:

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

2. The combination, substantially as set forth, of a permanent magnet, or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim whether the permanent magnet be set in vibration in the neighborhood of the

conducting-wire forming the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting-wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself in the neighborhood of such bodies, as set forth.

4. The method of producing undulation, in a continuous voltaic circuit, by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

5. The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth.

In testimony whereof I have hereunto signed my name this twentieth day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:

THOMAS E. BARRY.
P. D. RICHARDS.

2 Sheets—Sheet 1.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. Patented Jan. 30, 1877.

Fig. 1.

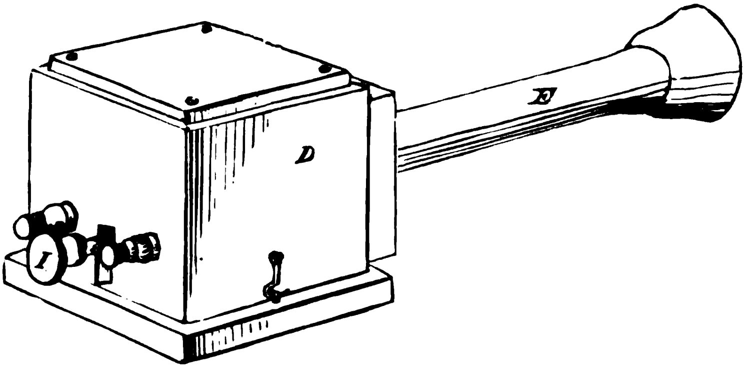


Fig. 2.

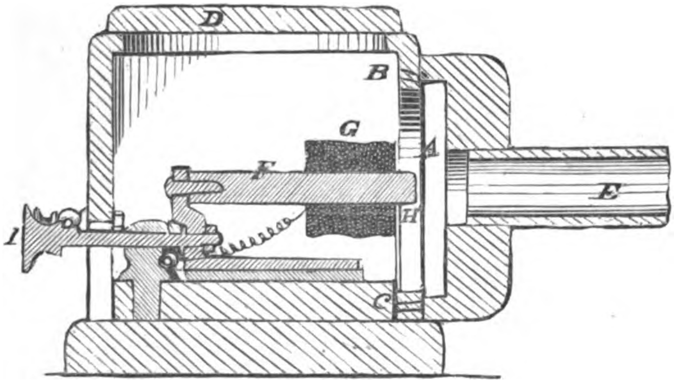
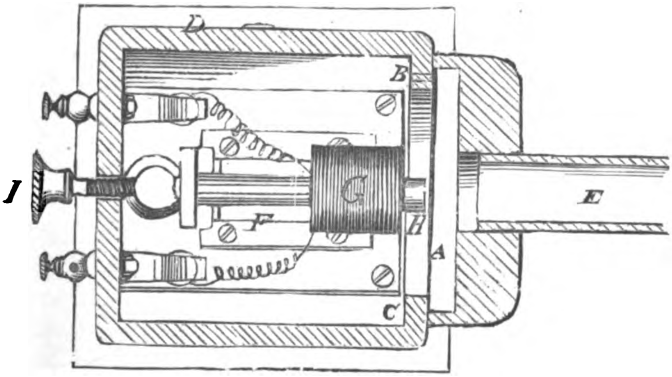


Fig. 3.



Attest:

A. Pollok

Ewell A. Dick

Inventor

Alexander Graham Bell

2 Sheets—Sheet 2.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787 Patented Jan. 30, 1877.

Fig. 4.

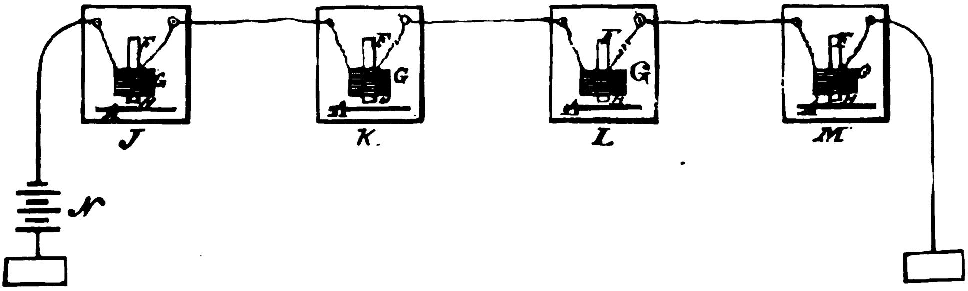


Fig 5.

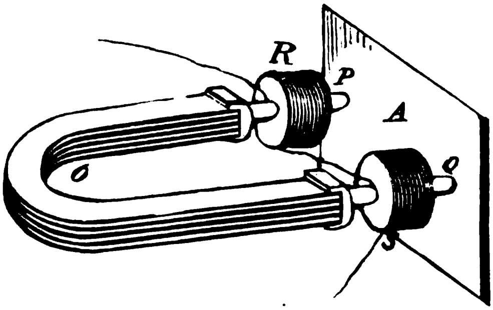
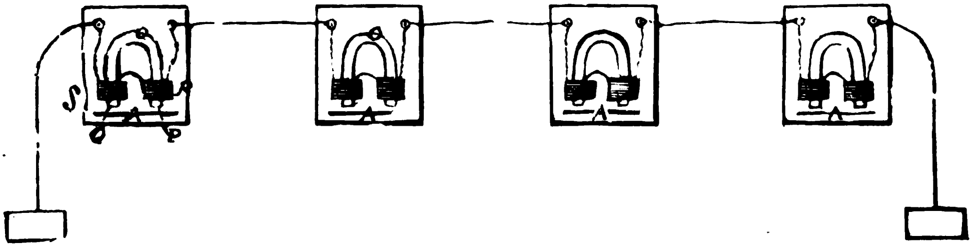


Fig. 6.



Attest:

A. Pollok

Ewell A. Dick

Inventor:

Alexander Graham Bell

UNITED STATES PATENT OFFICE.

Alexander Graham Bell, of Boston, Massachusetts.

IMPROVEMENT IN ELECTRIC TELEGRAPHY.

Specification forming part of Letters Patent No. 186,787, dated January 30, 1877; application filed January 15, 1877.

To all whom it may concern:

Be it known that I, Alexander Graham Bell, of Boston, Massachusetts, have invented certain new and useful Improvements in Electric Telephony, of which the following is a specification: —

In Letters Patent granted to me on the 6th day of April, 1875, No. 161,739, and in an application for Letters Patent of the United States now pending, I have described a method of and apparatus for producing musical tones by the action of a rapidly interrupted electrical current, whereby a number of telegraphic signals can be sent simultaneously along a single circuit.

In another application for Letters Patent now pending in the United States Patent Office, I have described a method of and apparatus for inducing an intermittent current of electricity upon a line-wire, whereby musical tones can be produced and a number of telegraphic signals be sent simultaneously over the same circuit, in either or in both directions; and in Letters Patent granted to me March 7, 1876, No. 174,465, I have shown and described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit, in either or in both directions, and a single battery be used for the whole circuit.

In the applications and patents above referred to, signals are transmitted simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others, and are received without confusion by means of receiving-instruments, each tuned to

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a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments. A separate instrument is therefore employed for every pitch, each instrument being capable of transmitting or receiving but a single note, and thus as many separate instruments are required as there are messages or musical notes to be transmitted.

My invention has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals along a single wire, in either or both directions, and with a single battery for the whole circuit, without the use of as many instruments as there are musical notes or telegraphic signals to be transmitted; second, the electrical transmission by the same means of articulate speech, and sound of every kind, whether musical or not; third, the electrical transmission of musical tones, articulate speech, or sounds of every kind, without the necessity of using a voltaic battery.

In my patent No. 174,465, dated March 7, 1876, I have shown as one form of transmitting-instrument, a stretched membrane to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument, or by sounds produced in any way.

In accordance with my present invention I substitute for the membrane and armature shown in the transmitting and receiving instruments alluded to above a plate of iron or steel capable of being thrown into vibration by sounds made in its neighborhood.

The nature of my invention and the manner in which the same is or may be carried into effect will be understood by reference to the accompanying drawings, in which —

Figure 1 is a perspective view of one form of my electric telephone. Fig. 2 is a vertical section of the same, and Fig. 3 is a plan view of the apparatus. Fig. 4 is a diagram illustrating the arrangement upon circuit.

Similar letters in the drawings represent corresponding portions of the apparatus.

A in said drawings represents a plate of iron or steel, which is fastened at B and C to the cover or sounding-box D. E represents a speaking-tube, by which sounds may be conveyed to or from the plate A. F is a bar of soft iron. G is a coil of insulated copper wire, placed around the extremity of the end H of the bar F. I is an adjusting-screw, whereby the distance of the end H from the plate A may be regulated.

The electric telephones, J, K, L and M, are placed at different stations upon a line, and are arranged upon circuit with a battery, N, as shown in diagram, Fig. 4.

I have shown the apparatus in one of its simplest forms, it being well understood that the same may be varied in arrangement, combination, general construction and form, as well as material of which the several parts are composed.

The operation and use of this instrument are as follows: —

I would premise by saying that this instrument is and may be used both as a transmitter and as a receiver — that is to say, the sender of the message will use an instrument in every particular identical in construction and operation with that employed by the receiver, so that the same instrument can be used alternately as a receiver and a transmitter.

In order to transmit a telegraphic message by means of these instruments, it is only necessary for the operator at a telephone (say J) to make a musical sound, in any way, in the neighborhood of the plate A, — for convenience of operation, through the speaking-tube E, — and to let the duration of the sound signify the dot or dash of the Morse alphabet, and for the operator who receives his message (say at M) to listen to his telephone, preferably through the speaking-tube E. When two or more musical signals are being transmitted over the same circuit, all the telephones reproduce the signals for all the messages; but as the signals for each message differ in pitch from those for the other messages, it is easy for an operator to fix his attention upon one message and ignore the others.

When a large number of despatches are being simultaneously transmitted, it will be advisable for the operator to listen to his telephone through a resonator, which will re-enforce to his ear the signals which he desires to observe. In this way he is enabled to direct his attention to the signals for any given message without

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being distracted or disturbed by the signals for any other messages that may be passing over the line at the time.

The musical signals, if preferred, can be automatically received by means of a resonator, one end of which is closed by a membrane, which vibrates only when the note with which the resonator is in unison is emitted by the receiving-telephone. The vibrations of the membrane may be made to operate a circuit-breaker, which will actuate a Morse sounder or a telegraphic recording or registering apparatus.

One form of vibratory circuit-breaker which may be used for this purpose I have described in Letters Patent No. 178,399, June 6, 1876. Hence, by this plan the simultaneous transmission of a number of telegraphic messages over a single circuit in the same or in both directions, with a single main battery for the whole circuit and a single telephone at each station, is rendered practicable. This is of great advantage in this: that for the conveyance of several messages, or signals, or sounds over a single wire simultaneously, it is no longer necessary to have separate instruments correspondingly tuned for each given sound, which plan requires nice adjustment of the corresponding instruments, while the present improvement admits of a single instrument at each station; or if, for convenience, several are employed, they are all alike in construction, and need not be adjusted or tuned to particular pitches.

Whatever sound is made in the neighborhood of any telephone — say at J, Fig. 4 — is echoed in fac-simile by the telephones of all the other stations upon the circuit; hence this plan is also adapted for the use of the transmitting intelligibly the exact sounds of articulate speech. To convey an articulate message it is only necessary for an operator to speak in the neighborhood of his telephone, preferable through the tube E, and for another operator at a distant station upon the same circuit to listen to the telephone at that station. If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the same circuit; hence, by this plan, a number of vocal messages may be transmitted simultaneously on the same circuit in either or both directions. All the effects noted above may be produced by the same instruments without a battery by rendering the central bar F H permanently magnetic. Another form of telephone, for use without a battery, is shown in Fig. 5, in which O is a compound permanent magnet, to the poles of which are affixed poll-pieces of soft iron, P Q, surrounded by helices of insulated wire, R S.

Fig. 6 illustrates the arrangement upon circuits of similar instruments to that shown in Fig. 5.

In lieu of the plate A in above figures, iron or steel reeds of definite pitch may be placed in front of the electro-magnet O, and, in connection with a series of such instruments of different pitches, an arrangement upon circuit may be employed similar to that shown in my patent No. 174,465, and illustrated in Fig. 6 of Sheet 2 in said patent. The battery, of course, may be omitted.

This invention is not limited to the use of iron or steel, but includes within its scope any material capable of inductive action.

The essential feature of the invention consists in the armature of the receiving instrument being vibrated by the varying attraction of the electro-magnet, so as to vibrate the air in vicinity thereof in the same manner as the air is vibrated at the other end by the production of the sound. It is therefore by no means necessary or essential that the transmitting instrument should be of the same construction as the receiving instrument. Any instrument receiving and transmitting the impression of agitated air may be used as the transmitter, although for convenience, and for reciprocal communication, I prefer to use like instruments at either end of an electrical wire. I have heretofore described and exhibited such other means of transmitting sound, as will be seen by reference to the Proceedings of the American Academy of Arts and Sciences, Volume XII.

For convenience, I prefer to apply to each instrument a call-bell. This may be arranged so as to ring, first, when the main circuit is opened; second, when the bar F comes into contact with the plate A. The first is done to call attention; the second indicates when it is necessary to readjust the magnet, for it is important that the distance of the magnet from the plate should be as little as possible, without, however, being in contact. I have also found that the electrical undulations produced upon the main line by the vibration of the plate A are intensified by placing the coil G at the end of the bar F nearest the plate A, and not extend it beyond the middle, or thereabout.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is —

1. The union upon and by means of an electric circuit of two or more instruments, constructed for operation substantially as herein shown and described, so that if motion of any kind or form be produced in any way in the armature of any one of the said instruments, the armatures of all the other instruments upon the same circuit will be moved in like manner and form, and if such motion be produced in the former by sound, like sound will be produced by the motion of the latter.

2. In a system of electric telegraphy or telephony, consisting of transmitting and receiving instruments united upon an electric circuit, the production, in the armature of each receiving-instrument, of any given motion by subjecting said armature to an attraction varying in intensity, however such variation may be produced in the magnet; and hence I claim the production of any given sound or sounds from the armature of the receiving instrument by subjecting said armature to an attraction varying in intensity, in such manner as to throw the armature into that form of vibration that characterizes the given sound or sounds.

3. The combination, with an electro-magnet, of a plate of iron or steel, or other material capable of inductive action, which can be thrown into vibration by the movement of surrounding air or by the attraction of a magnet.

4. In combination with a plate and electro-magnet, as before claimed, the means herein described, or their mechanical equivalents, of adjusting the relative position of the two so that, without touching, they may be set as closely together as possible.

5. The formation, in an electric telephone such as herein shown and described, of a magnet with a coil upon the end or ends of the magnet nearest the plate.

6. The combination, with an electric telephone such as described, of a sounding-box, substantially as herein shown and set forth.

7. In combination with an electric telephone, as herein described,

the employment of a speaking or hearing tube for conveying sounds to or from the telephone, substantially as set forth.

8. In a system of electric telephony, the combination of a permanent magnet with a plate of iron or steel, or other material capable of inductive action, with coils upon the end or ends of said magnet nearest the plate, substantially as set forth.

In testimony whereof I have hereunto signed my name this 13th day of January, A. D. 1877.

A. GRAHAM BELL.

Witnesses:

Henry R. Elliott,
Ewell A. Dick.

Circuit Court of the United States,

AFFIDAVITS FOR COMPLAINANTS ON MOTION FOR PRELIMINARY INJUNCTION.

AFFIDAVIT OF ALEXANDER GRAHAM BELL.

I, Alexander Graham Bell, on oath depose and say: —

I am the patentee named in the patents of the United States, No. 174,465, dated March 7, 1876, and 186,787, dated Jan. 30, 1877. I know that I am an original, and I verily believe that I am the first inventor of the inventions set forth and claimed in those two patents.

My father was a teacher of articulation; and as he intended that I should follow his own profession, I very early became acquainted with the researches of Helmholtz relating to the "quality" of sounds, and made some discoveries 1
of my own relating to this subject. I also, before 1870, made a considerable study of electricity with a view to the telegraphic transmission of sounds, and constructed apparatus for this purpose. My studies, experiments and inventions in both these directions continued and absorbed most of my attention, broken chiefly by my duties in the Boston School for the Deaf, and elsewhere, in instructing

the deaf and dumb to articulate. I also in 1873, 1874 and
1875 devoted a good deal of time, study and experiment to
2 the vibration of stretched membranes by vocal and other
sounds, with a view to utilize the fact that the vibratory
motions compelled in them by the utterance of such sounds
conformed not merely in frequency but in "form" and
"character" to the form and character of the aerial vibrations
which constitute such sounds.

The possibility of the transmission of articulate speech
telegraphically had long been in my mind, and in 1874 I
devised a plan which, theoretically at least, would accomplish
this. It embodied the principle of the magneto
3 transmitter and receiver, shown in Fig. 7 of my patent,
174,465, of March 7, 1876, and was in effect the same as
those instruments, each having a magnet, and an armature
attached to a membrane, to be used as there described. In
October, 1874, I described this to Dr. Clarence J. Blake
(lecturer on Otology in Harvard University and aural surgeon
at the Massachusetts Eye and Ear Infirmary), and
illustrated my description by drawings made on the spot.
I did not then construct the apparatus, because I was not
sure that the currents generated by that method would be
4 strong enough to be of practical utility.

In March, 1875, I explained some of my inventions to
Prof. Henry at Washington; and in a letter which I wrote
March 18, 1875, describing that interview, I said: —

"Such a chimerical idea as telegraphing vocal sounds
would, indeed, to most minds, seem scarcely feasible
enough to spend time in working over. I believe, however,
that it is feasible, and that I have got the cue to the
solution of the problem."

Fearing, at that time, that the magneto currents gener-
5 ated by an instrument like the transmitter of Fig. 7 of my
said patent, 174,465, would be too weak, I conceived that a
proper way to obtain stronger currents and effects would be
to use the constant power of a strong battery, and utilize
the vibrations given to the transmitter by the voice to vary
the resistance of the circuit through which the current from

that battery passed. With reference to this plan, I wrote in a letter, May 4, 1875: "If this turns out to be the case, the oscillations of the current should correspond in *amplitude* as well as in the rate of movement to the vibrations of the string. One consequence would be that the 6
timbre of a sound could be transmitted. The plan for transmitting *timbre*, that I explained to you before, — viz., causing permanent magnets to vibrate in front of electro-magnets, — is chiefly defective on account of the feebleness of the induced currents. If the other plan is successful, the strength of the current can be increased *ad libitum*, without destroying the *relative intensities of the vibrations.*"

In a letter of May 24, 1875, I wrote: "Every moment of my time is devoted to study of electricity and to experiments. The subject broadens. I think that the trans- 7
mission of the human voice is much more nearly at hand than I had supposed. . . . I fear that this telegraphic business may force me to remain the greater portion of the summer here; but I cannot tell yet, so many details have to be worked out. My inexperience in such matters is a great drawback. However, Morse conquered his electrical difficulties, though he was only a painter; and I don't intend to give in either, till all is completed."

Before this time I had perfectly satisfied myself that the true and only method for the telegraphic transmission of 8
vocal sounds involved as its fundamental element an apparatus which should transmit amplitude or intensity as well as pitch, — for "quality" or *timbre* or articulation were ultimately resolvable into these two characteristics of vibration, — and therefore that the electrical transmission of speech depended upon producing upon the line wire electrical undulations or variations which should correspond in form to the aerial vibrations which constituted the sound to be transmitted; and I perceived that a circuit-breaking apparatus (such, for example, as the Reis transmitter) was 9
necessarily totally inadequate to do this, because it merely tended to intermit the current, and not to control it, — to govern its changes as to frequency, but not as to intensity

or form or character. I was aiming to perfect an apparatus which should carry out my method in two ways: one by varying the electro-motive force in a circuit of constant resistance, and the other by varying the resistance in a circuit supplied with a constant electro-motive force. I intended to do both of these by means of the vibrational
10 movement taken up by stretched membranes or elastic metals when spoken to.

In my description given to Dr. Clarence J. Blake, in October, 1874, I had described a working apparatus intended to produce these electrical undulations when spoken to, by varying the electro-motive force. My only doubt about this apparatus was purely electrical and practical; viz., whether currents generated by such slight movements of a thin armature would be sufficiently strong to produce audible effects at the receiving station. On June 2, 1875, in the
11 course of some experiments, I discovered that slight movements of a thin armature would produce currents of available strength. This at once removed the last supposed difficulty from my mind, and the electrical speaking telephone became to me a completed discovery and a fixed fact. I announced this to one of my friends in a letter written on that day, in whcih I used the following language: "I have succeeded to-day in transmitting signals *without any battery whatever!* The musical note produced at the receiving end was sensibly the equivalent of that at the transmit-
12 ting end in *loudness* as well as pitch."

I continued the experiment in question for several hours, and I confess with some excitement in what I felt was the realization of my hopes and the completion of a great invention; before I left the room I directed Mr. Watson, my assistant, to make an apparatus with a stretched membrane, in accordance with directions I then gave him, and which substantially conformed to the description I had given Dr. Blake in October, 1874. The instrument was at once made, and soon after another like it. These were
13 electric speaking telephones, substantially the same as those of Fig. 7 of my patent 174,465, and were capable of transmitting and reproducing articulate speech.

In the autumn of 1875 I drew the specification for my patent 174,465, but the application was delayed in order to arrange for funds with persons who, I was led to believe, would take an interest and assist me. I had no sufficient means myself.

My specification was sent to Washington on Jan. 9, 1876. It was examined there by Mr. A. Pollok, the patent solicitor who was to take charge of it. He had a fair 14 copy made by his clerk and sent to me Jan. 18, 1876. This copy differed from the specification which I sent Jan. 9, only by a few changes purely verbal in their character. It was sworn to by me in Boston, Jan. 20, 1876, and filed in the Patent Office Feb. 14, 1876.

I have read the affidavit of Mr. Watson in this case; and the statements in it, with regard to my recognition as the inventor of the electric speaking telephone, and with regard to its introduction into public use, are correct.

I will add that Professor T. Sterry Hunt was among 15 those present at my exhibition of my electric speaking telephone at the Centennial, June 25, 1876, and a few hours afterwards I received from him the following note:—

"CONTINENTAL HOTEL, PHILA., June 25, 1876.

"DEAR MR. BELL:—I am informed that you leave to-night for Boston, so I take this way of congratulating you on your success to-day. I returned to my hotel with Sir Wm. Thomson, and dined with him. He speaks with much enthusiasm of your achievement. What yesterday 16 he would have declared impossible, he has to-day seen realized, and he declares it the most wonderful thing he has seen in America. You speak of it as an embryo invention, but to him it seems already complete; and he declares that, before long, friends will whisper their secrets over the electric wire.

"Your undulating current he declares a great and happy conception.

"All this he discussed partly with Dr. Bache, and more

17 at length with Sir Redmond Barry and Sir John Hawkshaw. Sir William leaves here on Friday for Montreal, and will visit Boston for a day or two before sailing, which will be from New York, July 19.

"Thinking you would be glad to hear the judgment of one so eminent, I have written you this, and I am, my dear Mr. Bell,

"Always truly yours,

"T. Sterry Hunt.

"P. S. — Do you know anything of Brücher's system of
18 visible speech, of which one of the Austrian judges spoke to-day? It seems very like your father's.

Graham Bell, Esq."

The exhibition of Jan. 13, 1877, was at the Medical College at Washington, before the Philosophical Society of Washington. I was assisted in it by E. N. Dickerson, Esq., and Professor Henry presided.

I have stated very briefly the time at which and the manner in which my invention was made and was reduced to practice. The letters from which I have given extracts and a much fuller account of the whole matter, will be
19 found in my direct examination and cross examination, as a witness in the suit Bell Telephone Company *et al. v.* Dowd, to which I refer. In that suit, Dr. Clarence J. Blake testified as a witness, and identified the drawings and repeated the description which I gave him in October, 1874.

I verily believe, also, that I am the first and original inventor of the inventions set forth and claimed in my patent 186,787, dated Jan. 30, 1877. For a fuller statement of the origin of said invention, I refer to my said
20 deposition and to the depositions of Mr. Watson and Mr. Wilson, in said suit of Bell Telephone Company *et al. v.* Dowd.

Sworn to, Alexander Graham Bell.

AFFIDAVIT OF CHARLES R. CROSS FOR COMPLAINANTS.

My name is Charles R. Cross; age, thirty-two; I reside in Boston, Massachusetts, and am the Thayer Professor of Physics at the Massachusetts Institute of Technology, Boston.

I have been acquainted with the electric speaking telephone since the early part of 1876. I have studied the subject extensively and made a number of experiments relating to it. I have read Mr. A. G. Bell's two patents, No. 174,465, dated March 7, 1876, and No. 186,787, dated Jan. 30, 1877, and understand them and the inventions therein described. I have frequently used electric speaking telephones made in accordance with them. 1

In order to a better understanding of those patents, it will be advisable for me to say something of the subject matter to which they relate.

The sensation of sound is caused by the action upon the ear of the vibrating particles of air set into a to-and-fro motion by a sound-producing body. When a given sound is produced, all these particles have the same character of motion: but as the motion is communicated from one to the other, the motion of two successive particles at the same instant is not identical, because the one lags a little behind the other in its changes; and this causes them to be alternately huddled together and more widely separated, producing along any line in space alternate condensations and rarefactions. These alternate condensations and rarefactions are called sound waves. If the requisite motion be imparted to one air particle, the elasticity of the atmosphere will cause this motion to be imparted to particle after particle, and sound waves will result. 2 3

As the condensations and rarefactions of the air are caused by the motions of the particles and their relative velocities, all the changes and variations in the one correspond and conform in their character to the changes and

variations of each of the others. It will therefore be sufficient
to consider the motion of one air particle, the means
of producing that motion, and the effect of that motion on
bodies with which the particle comes in contact.

In these sound vibrations each particle has an extremely
4 minute to-and-fro motion in the line of the propagation of
the sound. The particle, starting from a position of rest,
passes to the farther extremity of its path, back to the position
of rest, then swings beyond it to the other extremity
of its path, thence returns, and so continues to vibrate to
and fro until some impeding cause brings it to rest.

The vibrations of this particle may present three kinds
of difference: first, in the extent of its path from the extreme
limit on one side to the extreme limit on the other;
second, in the frequency with which it passes over its entire
5 path and returns to any point; third, in the character
of its motion while passing from one extremity of the path
to the other. *E. g.*, though its motion is always to and fro
along one straight line, yet it may move with a speed which
varies at every instant, and the character of this variation
may change at each instant; its motion while passing from
one end of its path to the other may be continuous in one
direction, or it may move onward a little at one speed, and
backward a little at another, and still reach the same limit
of its path at the same instant: in fact, the character of its
6 motion is susceptible of infinite variations, though all its
movements are executed to and fro in the same straight
line. Other things being the same, the distance apart of the
extreme limits of its path determines the loudness, the frequency
with which it passes from one extreme limit to the
other determines what the ear recognizes as the pitch of
the sound produced, while the character of its motion in
passing from one extremity to the other determines what
is called the character or quality of the sound.

"Quality" is the difference which distinguishes from
7 each other, sounds which the ear recognizes as different,
even though they may be of the same pitch and loudness;
as, for example, the note of a violin from that of a flute

or of the human voice, one voice from another, one vowel sound from another, one syllable from another. For sounds in general, including all articulate sounds, though recognized by the ear as having a definite pitch, are yet composed of several notes sounded simultaneously and differing from each other both in pitch and in intensity or loudness.

These partial tones, the combination of which affects the 8
ear as a single sound, consist of one lowest note, called the *fundamental*, and others of a higher pitch, often as many as twelve or sixteen, which are called *overtones*. The pitch which the ear recognizes as that of the whole sound is not the mean of the pitches of all the notes; it is simply that of one predominant note, which (except in a few special cases) is the lowest, or fundamental. The other partials are not recognized by the ear as affecting the pitch of the sound; they have a different function: they determine the character, "quality" or *timbre* of the sound heard. For 9
this character or quality depends upon the number and pitch of the various overtones, and the relative intensity of each; that is, depends, so to speak, upon the ingredients which are combined with the fundamental, and the amount of each which enters into the combination. These variations in the number, pitch and relative intensity of the overtones, upon which the character or "quality" of the sound depends, are themselves immediately determined by the various differences in the character of the motion of the vibrating particle while passing from one end of its 10
path to the other, as already explained.

In order to reproduce articulate speech, or any other sound having quality, it is therefore necessary to produce a vibratory movement of the air particle, which, in the *character* of its motion, as well as in the frequency with which it performs its total vibration, shall correspond to the particular sound desired.

If we determine the speed and direction of motion of the particle at each successive instant, we shall determine the character of its motion; if we compel it at each 11 successive instant to move with the desired speed, and in the desired direction, we shall control the character of its motion, and shall compel it to produce the desired sound.

The complete theory of the quality of articulate and other sounds, as here stated, was first demonstrated by Helmholtz as early as 1863, and is very commonly known as Helmholtz's theory of quality.

The method of reproducing vocal and other sounds, shown by Mr. Bell in his specification 174,465, consists in
12 utilizing the sound waves or motions of the air particles produced by the speaker at the transmitting station to move a diaphragm there placed, whose motion in turn serves to vary the electrical condition of the line wire leading to the receiver and the parts in circuit with it; and these electrical variations compel the diaphragm of the receiving instrument at each instant to take up the same character of motion, which, in turn, it imparts to the particles of air in contact with it, thus producing at the receiving station a sound which is a copy of that produced
13 by the voice of the speaker at the transmitting station.

According to his specification, he embodies that method in a transmitter, some part of which takes up from the air the motion given to the air particles by the voice of the speaker, and vibrates in exact accordance with them; a receiver, a part of which reproduces the vibrations of the transmitter, though generally with diminished intensity, and imparts them to the air particles at the receiving station; and a line wire which connects the two, and affords an uninterrupted passage for the currents of
14 electricity, the character of which and the variations in which are determined by the motion in the transmitter, and in turn determine the motion in the receiver.

In this apparatus, the function of the transmitter was to receive from the vibration of the air particles a vibrational movement of the same character as that of the particles or sound waves themselves; by the motion so taken up, to cause upon the line wire electrical undulations or variations of current corresponding in character, as well as

in frequency, to these motions. The function of the line
wire was to convey these electrical undulations to the receiving 15
instrument; while the function of the receiver was
to produce a vibrational movement of a diaphragm by
these electrical undulations, and thereby to produce vibrational
motion of the adjacent air, by causing these electrical
undulations to set up in the diaphragm of the receiver
vibrational motions which, in character, as well as in frequency,
correspond to the electrical undulations, and therefore
to the movement in the transmitter which produced
them. By this method, the air at the receiving station
is compelled to copy the vibrations produced in the air at 16
the transmitting station by the voice of the speaker,
and a sound precisely similar to that uttered at one end
of the apparatus is heard at the other.

Thus the sound which is the result at the receiving end is precisely similar to the sound which is the cause at the transmitting end.

It may be true that the receiver does not always reproduce
the motions of the transmitter in every possible minute
variation; but the instrument will be a speaking telephone
only so far as in principle it is adapted to reproduce them 17
with accuracy, and in construction is so far perfect that it
will reproduce them with substantial fidelity. Moreover,
the variations between the sound waves which constitute a
given articulate sound, and those which constitute a sound
not recognizable as articulate speech, are such, that an
excessively minute departure from the theoretical requirements
will substantially deprive the instrument of all practical
value.

Mr. Bell's method and apparatus described in his patent
174,465 involves the use of and consists of three instruments: 18
a transmitter at the sending or speaking station, a
receiver at the receiving or listening station, and a line
wire which connects the two in an unbroken circuit.

His specification 174,465 shows in Fig. 7 an apparatus, the receiving portion of which contains a diaphragm capable of being vibrated at varying rates, with varying amplitude, and with vibrational movements of substantially any character concerned in the production of sound, using the word "character" in the sense in which I have 19 defined it. It is provided with an inductive armature attached to the diaphragm, and placed in front of an electro-magnet, which is kept continuously magnetized by a battery current passing through its coils.

This magnet draws the diaphragm towards itself with a power proportioned to its strength, and the strength of the magnet at each instant depends upon the strength of the current passing over the line from the transmitter to the receiver; it is therefore the strength of this current at each instant which controls the position of the diaphragm. 20 Every variation in its strength causes a change of position in the diaphragm, in one direction if the current increases, in the other if it decreases. In other words, every variation in the strength of the current causes a like motion in the diaphragm, and this motion corresponds to the changes in the current, not merely in their periods, but in the whole character of every change while it is passing from the maximum to the minimum strength. If, therefore, the strength of the current can be caused to exactly correspond to the character of the varying motions of an air particle 21 when a particular sound is heard, the diaphragm of the receiver will be compelled to move with the same character of motion, will impart that motion to the air near it, and the sound in question will be there heard.

It will be observed that, comparing one instant with the next succeeding instant, the current may change by increasing or decreasing, and may vary in the amount of increase or decrease, may vary in the rapidity with which these changes in amount or in direction follow each other, and in the time it occupies in passing from one par- 22 ticular degree of strength through its whole series of changes, back to the condition of starting; in other words, the variations will be in the direction of change, in the amplitude of change, in the frequency of change. And the same is obviously true of the motions given to the diaphragm by the current. What is needed, therefore, is that the transmitting instrument, moved by the voice of

the speaker, shall control, at every instant and without any interruption, the direction of change, the amplitude or violence of change, and the frequency of change in the current, and thus make these conform to the varying changes of 23
motion in the air particles due to the voice of the speaker.

These three kinds of change — in direction, in amplitude, and in frequency — cover all the variations of motion and all the variations of current strength involved.

Mr. Bell's specification 174,465 describes both a method for transmitting telegraphically vocal and other sounds, and also several forms of apparatus by which that method can be practised. The principle of his method or mode of operation, and the principle and mode of operation of his apparatus, is, that the electrical condition of the line wire 24
and parts connected with it, and hence the movement of the diaphragm of the receiver, shall be, not merely at intervals separated from each other, but continuously and without intermission, controlled by the movement of that part of the transmitter which is vibrated by and in accordance with the voice of the speaker. It is only by this continuous control that the character of the movement of the transmitter, in the sense in which I have used the word "character," is reproduced in the variations of the electric current and in the movements of the receiver. 25

This continuous control was not accomplished nor even attempted in any form of telephone known before Mr. Bell's invention.

No form of transmitter which involves the use of a circuit breaker can exercise this necessary constant control over the movement of the receiver. The circuit breaker will throw upon the line, at each time it makes contact, an electrical impulse due to the force of the battery, but these impulses will be merely intermittent. The effect of each on the line and on the receiver will die away with a rapidity 26
and with a character of decrease due to the physical constitution of the line and the receiver; the electrical and magnetic condition of the apparatus during these periods of intermission (and consequently the motion of the sound-

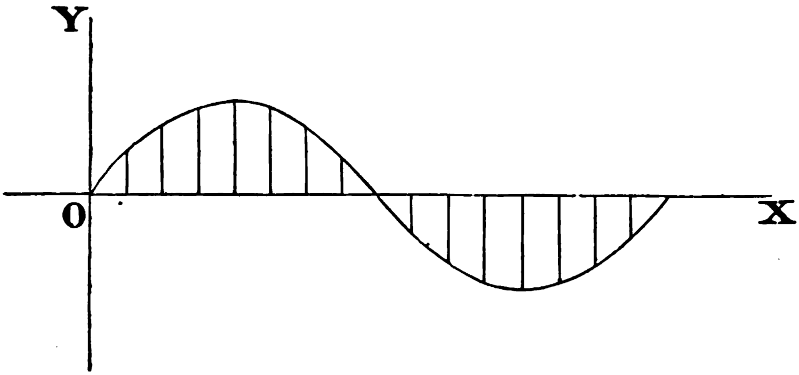
producing part of the receiver) will depend upon their
physical constitution, and not upon the character of the
movements performed by the transmitter during those
periods. If such a circuit-breaking transmitter be moved
by sound waves, as in the case of the Reis apparatus, the
27 frequency of its contacts will correspond to the pitch of the
sound, a movement of the same frequency will take place
in the receiver, and a sound of the same pitch will be reproduced.
But all those characteristics which go to make
up the quality of the sound, and which depend, as I have
stated, not upon frequency of motion but upon character of
motion, will fail of reproduction. The "quality" of the
sound heard at the receiver will be that peculiar to the apparatus;
consequently such an apparatus cannot transmit
the words uttered by the speaker.

28 I have said that a circuit-breaking transmitter cannot
transmit "quality," because the electrical and magnetic
changes and consequent motions in the receiver during the
intermissions of contact will be such as are due to the
character of the apparatus, and not to the movement given
to the transmitting diaphragm during these intervals by the
voice of the speaker. Such an instrument would fail to be
a speaking telephone for another reason. In all forms of
apparatus which I know of, the sudden changes caused by
totally breaking and then suddenly closing the circuit are
29 so much more violent than those due to merely weakening
and strengthening the current, that the noise produced
upon such an interruption renders it impossible for the
listener to perceive those variations which constitute
"quality," and make the sound intelligible as an articulate
word. Indeed, this difference in the noise produced by
making and breaking the circuit, instead of merely varying
the current without breaking it, is so well understood that
telephonic alarm signals are constructed to take advantage
of it: a telephonic receiver, which, when actuated by articulate
30 undulations, must be held close to the ear to be heard,
will make a noise audible throughout a large hall, if an
intermittent current from a circuit breaker be passed
through it.

The method of transmitting vocal and other sounds by a constant and continuous control over the receiver through a current which is undulatory and continuous, and not intermittent or broken, and which itself is produced or controlled by and therefore conforms to the motion of the transmitter actuated by sound waves, is essential to the transmission of articulate speech, and I believe is novel 31
with Mr. Bell. This is the general opinion among scientific men who have studied the question. I will presently refer more in detail to the known state of the art on this subject before Mr. Bell's patent.

Before referring to the language in which Mr. Bell's specification describes his method, I will state the well-known meaning of some of the terms of art which he employs.

It is common among physicists to represent graphically sound vibrations, or indeed any series of variations, by 32
curves. The following sketch represents the curve called a sinusoidal curve, such as corresponds to the sound waves produced by a simple sound, consisting of a single note without overtones. (Such a sound can be produced by a tuning-fork, mounted on a resonant case, and bowed in a manner suitable for this purpose.) O X is divided into a number of equal spaces to represent equal periods of time. The length of these spaces is purely arbitrary.



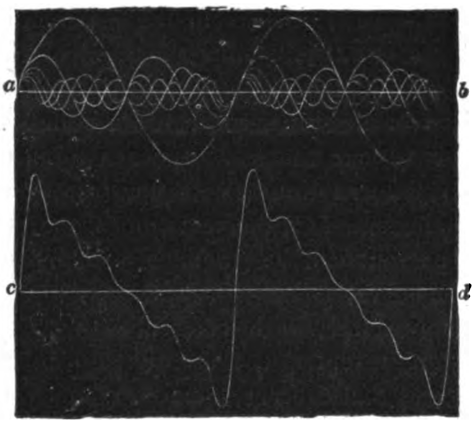
The distances from O to the beginning of any one of these
33 divisions are called *abscissas*. From each of these points
on O X, representing successive intervals of time, lines
are drawn parallel to O Y, and proportional in their relative
lengths to the distances of the particle from the point
of rest at the successive periods of time. In the case
of the particle pursuing a simple vibration, these magnitudes
will increase to a maximum which will be attained
at the instant when it reaches the extremity of its path;
they will then diminish, as it comes back to the starting
point; and as it passes beyond it, moving in the
34 other direction, they will be indicated by distances
measured off below the line O X. Joining then the extremities
of the perpendicular lines, we obtain a broken
line somewhat resembling a curve; and if we put the
perpendicular lines close enough together, the broken
line joining their extremities becomes a curve. This curve
is determined by the length of two sets of lines or distances,
— the *abscissas* measured on O X, and the *ordinates*
measured parallel to O Y. In the case stated, the
starting point is assumed to be in the middle of the path
35 (*e. g.*, the position of a pendulum when at rest), and the
motion is measured in both directions from it; *i. e.*, the
curve is on both sides of the line, and part of the ordinates
have one direction, part the other. But the point from
which the measurements are taken is purely arbitrary; and
the line O X, which represents this point, might be placed
lower down and tangent to the lowest part of the curve.
In that case the curve would not change its character,
but the ordinates would all be measured in one direction
and on one side of O X. Algebraically expressed, they
36 would all be + quantities, instead of being alternately +
and — quantities in the two branches of the curve; only
the + quantities would be greater than shown in the diagram.
In the case indicated by the diagram we should
consider that an increase in the length of the ordinates, in
passing from one to the next, signified motion in one direction,
and a decrease signified motion in the other direc-

tion. In this method of representation one set of lines,
measured along O X, corresponds to the period in which
the movement is executed, or its frequency, and the other,
measured along O Y, to the amplitude or extent and also 37
to the direction of the motion; and these measurements
express frequency, amplitude and direction. The same
curve will represent the extent of rarefaction and of condensation
of the air produced by the movement of the
particles, and also, when correctly interpreted, the motion
and the varying velocity of the particles.

It is from this habit of graphical expression that a vibration
is commonly spoken of among physicists as having
"form"; form of vibration is a phrase used to signify the
"character" of a vibration, as I have explained it. 38

It must be remembered that this curve does not represent
the path of the moving particle; that always moves
to and fro in a straight line. This curve is merely a convenient
form of expressing to the eye the character and
variation of the motion.

The following diagram, taken from Mayer on "Sound,"
p. 153, represents the motion of a particle under the influence
of sound waves: —



The curves at *a b* represent six sound waves of six
simple sounds. When these are sounded together as fun- 39

damental and overtones, and with relative intensities corresponding to the amplitude of the curves, as drawn, so as to produce a sound having the quality due to this combination, the vibrational "form," as it is called, of the sound perceived by the ear is represented by the curve at *c d*. The set of vibrations which constitutes one complete vibration is shown twice between *c* and *d*. The entire "form" or character of this curve can be determined and controlled, as already stated, by determining or controlling for each
40 point the length of the abscissa and of the ordinate for that point, or in other words, determining or controlling the elements of time or frequency, amplitude or intensity, and direction; but it is obvious that it will require very many measurements of abscissas and ordinates to determine or control the "form" of each complete set of vibrations.

The curve representing one set of vibrations is about three inches long; and it is apparent, even to a casual observer, that by taking the ordinates as little as one eighth of an
41 inch apart, we should miss the little twists which most strikingly represent to the eye the "quality" or the effect of the overtones in this vibrational form, and which are equally important to the "quality" of the sound as perceived by the ear; and as in the articulate speech of a woman there are twenty-four thousand of these *complete* sets in a minute, it will be obvious that in order to reproduce this vibration the control must be exercised not merely twenty-four thousand times a minute, but really without any interruption or cessation whatever.

42 By a similar method, the variation in the strength of an electrical current can be graphically expressed or represented by a curve.

It is, I presume, with reference to this well-known method of representation that Mr. Bell, in his said specification, states that the variations in the current caused by the movement of the transmitter can be represented graphically and without error by the same curve which represents the motion of the transmitter; and states, with

reference to the apparatus shown in Fig. 7, that the electrical undulations caused upon the line wire by the move- 43
ment given to the transmitter by the sound uttered against it "are similar in form to the air vibrations caused by that sound; that is, they are represented graphically by similar curves." And it is to the same thing that the words "similar in form," used in the fifth claim, refer.

Theoretically, the forms of apparatus indicated by Mr. Bell's specification will give to this undulatory current, and to the diaphragm of the receiver, variations and motions similar to the form of the sound waves due to the voice of the speaker; and though I suppose no apparatus 44
will conform perfectly to theoretical conditions, yet I know by experience that apparatus made exactly as there shown will produce such substantial similarity in these respects as to transmit articulate sounds and intelligible sentences. Its success in doing this depends upon the degree in which it approximates to the principles laid down by Mr. Bell in his specification.

I have described the method set forth in Mr. Bell's specification for transmitting vocal or other sounds telegraphically, by causing electrical undulations similar in form to 45
the vibrations of the air accompanying the said vocal or other sounds. I have also described the receiving instrument, in which these electrical undulations cause aerial vibrations, and consequently sounds, at the receiving station, and I have stated that this receiver must be connected to the transmitter in an unbroken circuit over which the electrical undulations can pass. An essential part of the apparatus is a transmitter which shall cause electrical undulations similar in form to the sound waves produced by the voice of the speaker. 46

The instrument shown at A, Fig. 7, is a mechanical, but a most essential mechanical modification of A, Fig. 5; both depend upon the same electrical principle, but by reason of the entire change of structure shown in Fig. 7, it has become capable of transmitting vocal sounds of all kinds, including articulate speech. When this transmitter,

Fig. 7, is in operation, electric currents are generated in
its coils by the motion of an inductive armature in front of
the pole of a magnetized electro-magnet. When the ar-
47 mature approaches the magnet, this motion generates a cur-
rent in one direction in the coils of the electro-magnet;
when it recedes, its motion generates in them a current in
the opposite direction.

The frequency of the changes in this current depends
upon the frequency of the changes in the motion of this
armature; and the extent of the changes, or the strength
of the currents so created, depends upon and therefore cor-
responds to the violence of motion of the armature. There
is a constant battery current flowing through the coils and
48 over the line, and when these magneto currents are in the
same direction with it, they add to it and strengthen it;
when in the opposite direction, they partially neutralize it
and weaken it. When, as in the case of Fig. 7, the arma-
ture is attached to a diaphragm, which will be compelled
by a sound uttered near it to move in substantial con-
formity to the aerial motion constituting that sound, the
undulations of the current caused by the motion of the dia-
phragm of the transmitter, and similar in form to those
motions, will also and consequently be similar in form to
49 the air vibrations which accompany or constitute the sound
uttered, and which move the diaphragm of the instrument.

This form of transmitter is commonly called at the present time the magneto transmitter.

The patent also describes another method by which the motion of the diaphragm can be used to cause electrical undulations similar in form to the motion of the diaphragm.

According to the well-known "Ohm's Law," the strength
of an electric current is measured by the electro-motive
force divided by the resistance. $s = \frac{E}{R}$. It was well known
50 before Mr. Bell's patent that the strength of a current
could be varied, either by varying the electro-motive
force, or by varying the resistance. Fig. 7 shows an
apparatus which causes the desired undulations by varying
the electro-motive force. The patent says that electrical

undulations may be also caused by alternately increasing and diminishing the resistance of the circuit; it also describes several forms of apparatus by which this can be accomplished.

I understand, therefore, that when the fifth claim refers to the method of transmitting vocal sounds by causing electrical undulations similar in form to the air vibrations accompanying said sounds, it intends to include and does include undulations produced in a continuous voltaic circuit by all the methods specified in the patent as adapted to produce them, whether by vibrating an inductive armature in front of an electro-magnet, or otherwise varying the electro-motive force, or by vibrating an electrode forming part of the circuit, or by imparting vibrations to other parts of the apparatus included in the circuit, so as to vary the resistance of that circuit by such vibration.

The attention of physicists had been directed to attempts to transmit articulate speech before Mr. Bell's time, but entirely without success. The state of the art in this branch of the art of telephony is set forth in a description written by M. Bourseuil, and published in du Moncel's "Exposé des Application de l'Electricité," Vol. II. p. 225, published in 1854. This statement or indication was not accompanied by descriptions of any alleged apparatus as a whole.

Mr. Bourseuil's description is in substance as follows: "We know that sounds are made by vibrations, and are perceived by the ear by these same vibrations, which are reproduced by the intervening medium. . . . . Suppose that a man speaks near a movable plate flexible enough to lose none of the vibrations produced by the voice, and that this plate makes and breaks successively a battery circuit, you could have at a distance another plate capable of executing at the same time the same vibrations. It is true that the intensity of the sounds will be variable at the transmitting station where the plate is vibrated by the voice and constant at the receiving station where it is vibrated by electricity." And he proceeds to say that the existing state of science could not tell in advance what effect this would have on articulation. He sums up the state of knowledge on the subject by saying: "It is at all events impossible in the present condition of science to prove the impossibility of transmitting sounds by electricity."

Subsequently, and in 1860–63 Philip Reis constructed and used in Germany an apparatus which embodied Bourseuil's ideas, though in a form which we now know is less efficient, so far as the receiver is concerned.

The Reis transmitter was described by Reis himself, and by various other persons, in printed publications before 1870, and was well known among scientific men. According to all of said descriptions it operated and was intended to operate by making and breaking an electric circuit at each vibration of the membrane of the transmitter. From this operation it necessarily followed that it was incapable of transmitting articulate speech, and its incapacity in this respect was well known and understood.

Later still Dr. Van der Weyde, in New York, in 1868, reconstructed the Reis apparatus with some improvements, which, however, did not change its mode of operation, nor the nature of the results produced. A description of it, published in the *Manufacturer and Builder* (of which Dr. Van der Weyde was the editor) for May, 1869, Vol. I. p. 130, contains the following passage: —

> "It is clear from the foregoing explanations that no quality of tone can be transmitted, much less can articulate words be sent, notwithstanding the enthusiastic prediction of some persons, who, when they first beheld this apparatus in operation, exclaimed that now we would talk directly through the wire. It is from its nature able to transmit only pitch and rhythm, consequently melody and nothing more. No harmony nor different degrees of strength or other qualities of tone can be transmitted; the receiving instrument, in fact, sings the melodies transmitted, as it were, with its own voice, regardless of the quality of the tone which produces the original tune at the other end of the wire."

The last word of science before Mr. Bell's patent was a description of this same instrument, written by Dr. Van der Weyde and published in the *Scientific American* of March 4, 1876, three days before the date of Mr. Bell's patent. This article, entitled "The Invention of the Telphone," redescribed the same apparatus, attributed to it the same mode of operation, — *i. e.*, that it acted as a circuit breaker, — and claimed for it no higher power or function than was attributed to it by the same writer in 1869.

The absolute and inherent incapacity of the old instruments, or, indeed, of any circuit breaker, to transmit articulate speech was thus perceived and publicly recognized; but what method or what character of instruments would accomplish this was not known and had not been suggested.

What was needed, therefore, for the transmission of articulate speech at the date of Mr. Bell's patent was not an improved apparatus constructed to operate according to the only method then known for the electrical transmission of sounds, but the invention of a new and fundamentally different method, and the construction of apparatus which should operate according to this method. It was necessary, not merely to introduce a new feature, but to totally discard that which was distinctive of the old method, and introduce in place of it another feature not only different from but inconsistent with the old method. It was not until after the introduction of Mr. Bell's new method, and only by the use of this new method, that articulate speech was, or, so far as my knowledge extends, ever has been, transmitted at all. The scientific world has generally recognized the "important point" or principle which distinguishes Mr. Bell's method from all preceding attempts, and which enabled it to accomplish what those previous methods of transmitting sounds were, both in theory and in practice, incapable of accomplishing. The introduction of this method has been the introduction of a new art. Since the date of Mr. Bell's patent many forms of speaking telephone have been made and patented; but, so far as my knowledge extends, they all embody the method, principle and mode of operation described by Mr. Bell in his said patent 174,465. So far as I am aware, these various modifications have been introduced in order to increase the practical efficiency of the method so described by Mr. Bell, and every change has been simply an endeavor to effect an improvement in the practical application of the new art set forth in said specification. The new method, which he described in said specification and referred to in the fifth claim thereof, underlies them all and includes them all.

The improvements in transmitters since Mr. Bell's patent 174,465 have been intended, and, so for as they have been successful, have been adapted, to cause electrical undulations similar in form to the vibrations of the air accompanying the vocal or other sounds which were uttered by the speaker at the transmitting end, and to do this by means of the vibrations given to the moving part of the transmitter by the voice of the speaker.

The improvements in the receivers have been intended to cause them to more perfectly and more fully move in conformity to these electrical undulations, and the receivers and transmitters have always been connected together in an unbroken circuit, in order that the movement given to one by the voice shall, at every instant and without intermission, control that movement in the receiver which produces the sound at the distant station.

Mr. Bell's second patent, No. 186,787, dated Jan. 30, 1877, refers to his previous patent 174,465, and sets forth certain improvements upon the apparatus shown in Fig. 7 thereof, which improvements render the apparatus better adapted to put in practice the method referred to in the fifth claim of the first patent.

One improvement shown in this patent consists in the acoustic arrangements of the box and frame. In Fig. 7 of the first patent the diaphragm is supported on a case which leaves its back side (next the magnet) exposed to the disturbing influence of all extraneous noises; and this case, in the transmitting instrument, offers a large cavity to talk into, and in the receiving instrument, a large cavity to receive the sound and conduct it to the ear. Figs. 1, 2 and 3 of patent 186,787 show a box which encloses and protects the back side of the diaphragm, while in front of it, in the place to be occupied by the sound waves which actuate it, or are produced by it, the cavity is diminished to a thin enclosure which communicates with the mouth of the speaker or the ear of the listener by a small hole in the centre. This modification of the front cavity was, so far as my knowledge extends, entirely novel with Mr. Bell. It possesses marked advantages in apparently intensifying the effect and preventing the formation of false tones. The advantages of it are so great and so well recognized that this form of cavity in front and this protection for the back of the diaphragm are in universal use, the chief change being that the improvement has been pushed still further by making the back cavity generally smaller and the front cavity still thinner.

The patent shows and states that a speaking tube "may" be inserted in the hole in front of the plate; but this tube is merely a matter of convenience if the telephone is too heavy to hold in the hand. In hand telephones it is generally replaced by the well-known form of flaring aperture long used in the acoustic instruments, known as Seebeck's ear, and described in works on acoustics. This sounding box is referred to in the sixth claim of said patent.

I have examined the description of a voltaic transmitter found in the affidavit of Edward Davis in this case. When this instrument is connected up in circuit with a receiver, such as the exhibit already described, or with any of the ordinary forms of speaking telephone receivers, I am of opinion that it will transmit articulate speech. When transmitting articulate speech this apparatus will operate according to the method described in Mr. Bell's patent 174,465, and referred to the fifth claim thereof; and it is capable of transmitting articulate speech because it will normally and habitually conform to the method and mode of operation therein described.

This transmitter is provided with a thin metallic diaphragm, and, when spoken to, this diaphragm takes up vibrations from the sound waves and conforms to them substantially in the character as well as in the frequency of its movements. These movements operate to cause, upon the line wire and in the receiver at the receiving station, electrical undulations similar in form to the sound waves accompanying or constituting the words spoken at the transmitting station. The instrument causes these undulations by means of the motion of an electrode, which is attached to the diaphragm, and whose motion serves to vary the resistance of the circuit external to the battery. This method is one of the methods for causing electrical undulations described in Mr. Bell's said patent. This particular form of instrument is not the same in all respects as that specifically described in said patent. I do not understand, however, that the patentee intends to confine himself to any specific form of instrument, but quite to the contrary; for, speaking of the various means for causing electrical undulations, he says, "The external resistance may also be varied. *For instance*, let," etc. And then he goes on to describe one particular instrument, in which the motion of an electrode attached to the diaphragm, as it vibrates to and from another electrode, which is fixed, will vary the resistance of the circuit. In the case of the defendants' said battery transmitter, the means by which the motion between the electrode fastened to the diaphragm, and moving with it, and the electrode fixed in the frame, varies the resistance, is not the same as that specifically described in the patent; but I do not consider that this changes the method or mode of operation of the apparatus as a whole, since in both cases vibrations of some part of the transmitter are produced by the voice, which in their turn produce corresponding electrical undulations in the line wire, by one of the two general means suggested by Mr. Bell for carrying out his method.

The mode of operation of this instrument and the functions of its operative parts are, that the vibrations imparted to the diaphragm by the voice do not break the circuit, but operate to vary its resistance, and thus, as Mr. Bell shows in his patent 174,465, by alternately increasing and diminishing the resistance of the circuit to cause electrical undulations, similar in form to the vibrations of the air accompanying the vocal sounds uttered at the transmitting station.

It was known long before the date of Mr. Bell's patent, that the resistance of a circuit is varied, without being broken, by variations in the intimacy of contact, or amount of pressure between two electrodes in contact, from one to the other of which a current is passing. This fact was noted and recorded by Du Moncel in his book, "Applications de l'Electricité," Vol. II. p. 246, edition of 1856, published at Paris in that year. In "Comptes Rendus" for July, 1874, a communication from the same writer described some experiments as to the resistance offered to the current in passing from one electrode to another, in the case where one was a good conductor and the other a poor conductor, and showed that a moderate increase of pressure at the contacts would materially increase the conductivity and thereby the current; and he gave his explanation for this phenomenon.

In Du Moncel, "Applications de l'Electricté," ed. 1856, Vol. I. p. 246, I find the following: —

"Une chose assez curieuse et qui paraît être au premier abord en contradiction avec la théorie que l'on s'est faite de l'électricité, c'est que la plus ou moins grande pression exercée entre les pièces de contact des interrupteurs influe considérablement sur l'intensité du courant qui les traverse. Cela tient souvent à ce que les métaux de l'interrupteur ne sont pas toujours dans un état parfait de décapage au point de contact, mais peut être aussi à une cause physique encore mal appréciée. Ce qui est certain, c'est que, dans les interrupteurs où la pièce mobile de contact est sollicitée par une force extrêmement minime, le courant éprouve souvent des affaiblissements assez notables pour faire manquer la réaction électrique qu'on attend d'eux."

Which I translate as follows: —

"A somewhat curious fact, which at first sight appears to be in contradiction to the views ordinarily received as to the action of electricity, is that the greater or less pressure exercised between the contact pieces of interrupters has an important influence upon the strength of the current which traverses them. This often happens because the metal of the interrupter is not perfectly free from rust at the point of contact, but perhaps also because of a physical cause as yet but little appreciated. This is certain, that with interrupters in which a movable contact piece is acted upon by a very slight pressure, the current often sustained such an enfeeblement as to cause a failure in the electrical action which was expected."

The same writer describes, in "Comptes Rendus" for July 6, 1874, a series of experiments in which he measured the current in a circuit, part of which consisted of a platinum electrode and a piece of wood, more or less damp, kept in constant contact, but with varying pressure, and says, page 41, in an article entitled "Récherches sur les transmissions electriques a travers les corps ligneux," as follows: —

"Les expériences que j'avais à faire pour avoir une constatation exacte des effets produits, étaient assez delicates, car une foule de causes étrangères peuvent intervenir, et changer les résultats fournis. Ainsi le dégré de serrage des plaques métalliques de communication avec le bois, sur isolement plus ou moins parfait du sol et des murs de l'appartement, où l'on expérimente, la grandeur des surfaces mises en communication avec le circuit métallique, la masse du bois, l'état plus ou moins humide de l'air des expériences, le contact fortuit des doigts sur les fils de communication avec le galvananetre, et l'état d'isolemens de ces fils sont autant de causes qui peuvent modifier les résultats que l'on obtient.

• • • • • • • •

"6. Que le dégré de la pression de la plaque de platiné contre le bois a tellement influé sur l'intensité du courant ainsi transmis, qu' étant de 12 dégrés avec un serrage maximum elle est devenue a zéro quand la plaque était abandonné a son propre poids, et a 5 dégrés seulement avec un faible serrage."

This I translate as follows: —

"The experiments that I have had to make in order to have an exact proof of the effects produced were very delicate, because a number of foreign elements might enter and change the results. Thus *the amount of pressure upon the metallic plates in communication with the wood* in more or less perfect insulation from the earth or the walls of the room, the size of the surfaces put in communication with the metallic circuit, the mass of the wood, the greater or less humidity of the air, the accidental contact of the fingers with the wires leaning to the galvanometer, and the condition of the insulation of these wires were causes which might modify the results that would be obtained.

. . . .

"6. That the amount of the pressure of the platinum plate against the wood has so much influence on the strength of the current thus transmitted, that from twelve degrees, with a maximum pressure, it became reduced to zero when the plate was pressed only by its own weight, and to five degrees only with a slight pressure."

In Du Moncel's "Traité de Telegraphie Electrique," Paris, 1864, Part IV., page 559, in speaking of apparatus designed to establish electrical contact, the author says, "L'expérience montre que plus la pression des contacts este grande, plus est énergique l'intensité du courant qui les traverse," that is, in English, "Experiment shows that the greater the pressure of the contact pieces, the stronger is the current passing through them."

This fact was also constantly acted upon in the practical use of electrical apparatus; care was always taken that contacts should be firm and with considerable pressure, for otherwise the full and desired strength of current was not obtained.

Speaking telephone battery transmitters which vary the resistance of the circuit by the movement of the diaphragm, without the use of the liquid, have been in common use upwards of two years and known somewhat longer. They contain generally a piece of carbon, or other substance of considerable resistance, which forms part of the circuit; the tendency of this piece to move away from the diaphragm, when the latter is vibrated, is opposed by a firm and fixed support, which holds it in place, or by a tolerably stiff and sluggish spring, or by the inertia of a weight, either of which serves like an anvil to resist a very quick and sharp impulse, such as comes from the vibrations of the diaphragm. Against the other side of this piece, which is very commonly called the "button," is an electrode, carried by or in contract with a diaphragm; as this diaphragm is vibrated by the voice, its varying motions bring to bear upon the button a pressure which varies in accordance to those motions, in character as well as in frequency, and the variations of resistance, due to this variation in pressure, cause electricial undulations in the circuit, which correspond in character, as well as in frequency, to the vibrations imparted to the transmitter by the voice of the speaker.

Mr. Emile Berliner's patent, No. 199,141, dated Jan. 15, 1878 (application filed Oct. 16, 1877), shows an apparatus of this sort which was described (so he states) in his application filed June 4, 1877. Mr. Thomas A. Edison's patent, No. 203,016, dated April 30, 1878 (application filed March 7, 1878), refers to an apparatus of this general character as shown in his application of July 20, 1877, and describes an instrument of this sort provided with a carbon button or disk, made of lampblack moulded into the proper shape.

I have examined the description of the Dolbear instrument, given in the affidavit of Edward Davis made in this case. The transmitter therein described is a variable-resistance solid contact transmitter of this well-known class and, in my opinion, it is adapted to operate when spoken to by causing variations in the contact pressure without breaking contact. When it transmits speech it necessarily so operates.

The receiving instrument described in said affidavit of Edward Davis is not in all respects the same as that of Mr. Bell's said patent, but it is substantially the same in performing the work of the electrical transmission of speech, according to the method shown in Mr. Bell's patent 174,465 and claimed in claim thereof. Both the instruments form parts of an apparatus, which, as a whole, transmits speech by means of certain peculiar variations of electrical currents. In this apparatus the office of the instrument at thereceiving station is to convert these electrical undulations into corresponding sound waves; and the particular means employed for that part of the operation do not affect the substantial identity of the apparatus as a whole. There is, however, a great identity between these parts of the apparatus considered by themselves. In both, the sound heard by the listener is produced by the vibration of an elastic plate; and in both, those vibrations are caused by the varying attractions to which it is subjected by the varying strength of the electrical undulations on the line wire. It is true that in the form shown in the two Bell patents the variation of currents causes magnetic variations in a piece of metal opposite the centre of a diaphragm, the attractive power of which piece is thereby caused to vary accordingly and thus cause variations in the attraction, while in the Dolbear instrument the variation of current causes electrical variations in a piece of metal opposite the centre of a diaphragm, the attractive power of which piece is caused to vary accordingly, and this causes variations in the attraction exercised on the diaphragm.

That the attractive power of one plate on another varied with the electricial condition of the first, was well known before the date of Mr. Bell's said first patent; it was also well known before the date of said patent that by this means the electrical variations in the secondary circuit of an induction coil could be made to cause such vibratory motion in a plate as to thereby produce a sound whose pitch corresponded to the rate of the electrical variations. And this device for converting electrical variations into sound waves was well known as an equivalent and substitute for the motion given to a vibrating armature by means of the varying attraction of an electro-magnet, through whose coils the same varying current should be passed.

I testified as expert for the complainants in the suit, in the U. S. Circuit Court for the District of Massachusetts, "American Bell Telephone Company *v.* Albert Spencer *et al.*" The transmitting instruments shown in said affidavit of Edward Davis are of the same character as, and operated in a similar manner to, the transmitter used by the defendant Spencer, and put in evidence in that case. The operative parts of both consist of a contact forming part of a battery circuit; one side of said contact in each is attached to an elastic diaphragm, which vibrates in accordance with the sound waves when the diaphragm is spoken to, while the other electrode in contact therewith is so arranged, either by the manner of its support, or its mass and inertia, or both, as to offer considerable resistance to the movement of the diaphragm; by this arrangement the vibrations of the diaphragm when spoken to produce variations of pressure at the contact, which causes corresponding variations of resistance at this part of the circuit.

CHARLES R. CROSS.

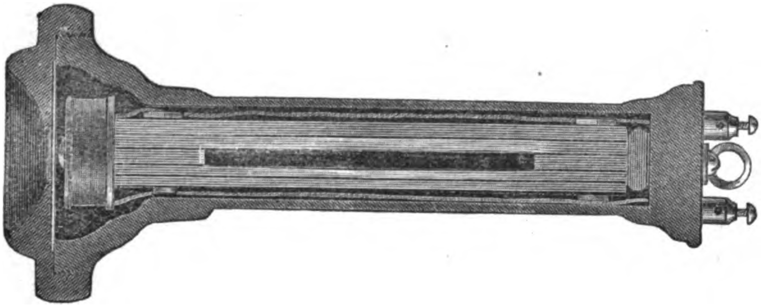
STATE OF NEW HAMPSHIRE, }
CARROLL COUNTY. } ss.

Subscribed and sworn to before me,
[SEAL]

G. W. M. PITMAN,
Notary Public.

RUBBER HAND TELEPHONE, IN USE SINCE DEC., 1877.

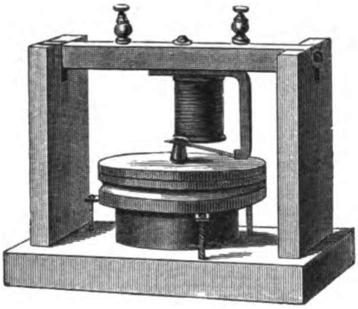
(Sectional View.)



DIMENSIONS.

Length of permanent magnet	4¾	inches.
“ soft iron core	9/16	“
“ spool	½	“
Diameter of spool	1	“
“ core	¼	“
“ diaphragm (in the clear)	1¾	“

COMPLAINANTS' EXHIBIT 1, BELL TELEPHONE OF 1875. (Duplicate.)



DIMENSIONS.

Diameter of membrane	4	inches.
Diameter of spool	1¼	“
Length of spool	1½	“
Length of armature	2	“
Width of armature	½	“
Depth of tube from mouth to membrane .	3	“

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AFFIDAVIT OF THOMAS A. WATSON.

Thomas A. Watson, a witness, of lawful age, having been duly sworn, doth depose as follows: —

My name is Thomas A. Watson; age, twenty-six; residence, Everett, Mass. I am General Inspector of the American Bell Telephone Company, and in that capacity or otherwise have been connected with the manufacture and use of electric speaking telephones under Mr. Bell's patents, from the time when they first began to be manufactured or exhibited.

In the winter of 1874–5 I was employed in making 1
electrical instruments at the factory of Charles Williams, Jr., Boston, and had considerable knowledge of electricity and electrical apparatus, gained by three years' experience in that factory, and by the study of various works on electricity and telegraphy. At that time I began to make electrical apparatus for Mr. Bell, and assisted him in various experiments in the transmission of sound by electricity.

In January, 1875, Mr. Bell told me of plans he had
devised for making a telegraph instrument which should 2
utter spoken words. June 2, 1875, in consequence, as I understood it, of an experiment made that day, in which I had assisted him, and which he has referred to in his affidavit in this case, he directed me to make an electric speaking telephone according to instructions which he gave me. I made it that day or the next, and we tried it. When he shouted at this instrument at one end of a telegraph line, I heard and recognized the sound at another instrument at the other. He told me on that second day
of June that he considered he had solved the problem of 3
the transmission of speech. About a month afterwards I made another similar instrument, which we experimented with. The annexed picture, complainants' Exhibit 1, shows these instruments almost exactly as they then were made.

In the fall of 1875 I knew that Mr. Bell was preparing the specifications for his patent 174,465, dated March 7, 1876.

This patent, dated March 7, 1876, was, I verily believe,
the first published description of any apparatus intended
4 for, and capable of, transmitting vocal utterances tele-
graphically.

May 10, 1876, a description by Professor Bell of his
researches in telephony was read before the American
Academy of Arts and Sciences, at Boston. This paper
was published soon afterwards, and contained a descrip-
tion of his electrical speaking telephone, as shown in Fig.
7 of said patent, and described the transmission of speech
by it. It also contained a description of an electrical
speaking telephone made upon the plan of varying the
5 resistance of an electrical circuit supplied with a constant
electromotive force from a battery; the particular form in-
dicated was that known as the liquid transmitter, referred
to in said specification, and was described as follows:

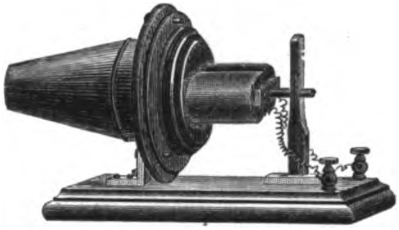
"A platinum wire, attached to a stretched membrane,
"completed a voltaic circuit by dipping into water. Upon
"speaking to the membrane, articulate sounds proceeded
"from the telephone in the distant room. The sounds
"produced by the telephone became louder when dilute
"sulphuric acid or a saturated solution of salt was substi-
6 "tuted for the water. Audible effects were also produced
"by the vibration of plumbago in mercury, in a solution
"of bichromate of potash, in salt and water, in dilute sul-
"phuric acid, and in pure water."

Two sets of Professor Bell's speaking telephones were made by me for exhibition at the Centennial Exhibition in Philadelphia, and were exhibited there in June, 1876. They consisted of a "magneto" transmitter and receiver, and of a liquid transmitter. Speech was transmitted by them while there, publicly.

7 I annex drawings of those instruments, marked "Complainants' Exhibits 2, 3, 4, 5."

Two reports were made upon Mr. Bell's said exhibit:

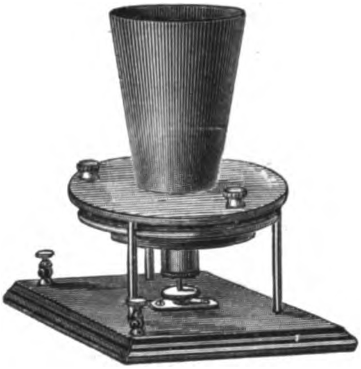
COMPLAINANTS' EXHIBIT 4, BELL'S DOUBLE POLE CENTENNIAL MEMBRANE TELEPHONE.



DIMENSIONS.

Length of cone	4¾	inches.
Diameter of membrane	3	"
Length of spools	1¾	"
Diameter of spools	1_{8}	"

COMPLAINANTS' EXHIBIT 5, BELL'S CENTENNIAL LIQUID TRANSMITTER.



DIMENSIONS.

Diameter of membrane	3	inches.
Diameter of cup	$\frac{8}{4}$	"
Depth of cup	$\frac{1}{2}$	"
Length of cone	6	"

one, by Professor JOSEPH HENRY, in "General Report of
Judges of Centennial Exhibition, Group XXV.," pages 20
and 21, describes the apparatus and the transmission of
speech by it, and says, "This telephone was exhibited in
"operation at the Centennial Exhibition, and was consid-
"ered by the judges the greatest marvel hitherto achieved
"by the telegraph." Its invention was, by that report,
attributed to Mr. Bell. 8

The other report was made by SIR WILLIAM THOMSON,
and is found in "Reports on Awards, Group XXV., Cen-
"tennial Exhibition," pages 130, 131. It contains the fol-
lowing: "Mr. Graham Bell exhibits apparatus by which
"he has achieved a result of transcendent scientific inter-
"est, — the transmission of spoken words by electric cur-
"rents through a telegraph wire. To obtain this result, or
"even to make a first step towards it, — the transmission of
"different qualities of sound, such as the vowel sounds, —
"Mr. Bell perceived that he must produce a variation of 9
"strength of current in the telegraph wire as nearly as
"may be in exact proportion to the velocity of a particle
"of air moved by the sound; and he invented a method
"of doing so . . . which has proved perfectly successful."
The report then proceeds to describe the magneto tele-
phone and the transmission of whole sentences by it, and
continues: "I need scarcely say I was astonished and
"delighted; so were others, including some other judges
"of our group, who witnessed the experiments, and veri-
"fied with their own ears the electric transmission of 10
"speech. This, perhaps the greatest marvel hitherto
"achieved by the electric telegraph, has been obtained by
"appliances of quite a homespun and rudimentary char-
"acter."

This apparatus, and the transmission of speech by it,
were noticed generally in the newspapers, and the inven-
tion attributed exclusively to Professor Bell. I instance
the *Scientific American* of Sept. 9, 1876, the Boston
Transcript of July 8, 1876, and the New York *Evening
Post* of Sept. 5, 1876. 11

A set of these instruments was given to SIR WILLIAM THOMSON, and he is reported to have exhibited them, and explained them and the transmission of speech by them, on assuming the chair of the section of Physical Science at the Glasgow meeting of the British Association in August, 1876, and in doing so, to have said: "This, the greatest by far "of all the marvels of the electric telegraph, is due to a "young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a natu- 12 "ralized citizen of the United States. Who can but admire the hardihood of invention which devised such very "slight means to realize the mathematical conception that, "if electricity is to convey all the delicacies of quality "which distinguish articulate speech, the strength of its current must vary continuously, and as nearly as may be in "simple proportions to the velocity of a particle of air engaged in constituting the sound?"

This address, or portions of it, containing the foregoing in full or in substance, was published in various news- 13 papers, among which I mention the Boston *Daily Advertiser*, of Sept. 25, 1876.

A description of the electric speaking telephone, with wood-cuts of the apparatus given by Professor Bell to Sir William Thomson, and the foregoing extracts from Sir W. Thomson's address to the British Association, were published in *Engineering* for Dec. 22, 1876, and reprinted in the *Scientific American* supplement, Feb. 10, 1877. These publications attributed the invention to Professor Bell exclusively.

14 During the fall of 1876, and the following winter and spring, Mr. Bell continued to experiment and operate publicly with his speaking telephone, and these exhibitions were noticed very generally in the newspapers as matters of practical value. I assisted in most or all of these. The invention was invariably attributed to Professor Bell alone. I mention —

Boston *Post*, Oct. 20, 1876.

Boston *Daily Evening Traveller*, Oct. 19, 1876.

Boston *Sunday Herald*, Oct. 22, 1876.

Titusville *Herald*, Oct. 22, 1876. 15

Boston *Evening Transcript*, Oct. 19, 1876.

These describe the transmission of speech from Boston to Cambridge.

A conversation over two hundred miles of wire on the lines of the Eastern Railroad is noticed in —

Boston *Post*, Boston *Daily Globe*, Boston *Daily Advertiser* and Boston *Herald*, of Nov. 27, 1876.

Also, other exhibitions were noticed nearly every week in various newspapers.

The *Boston Daily Advertiser* of Oct. 10, 1876, contains 16 the following: —

"At a meeting of the American Academy, on Wednes-"day night, Professor Bell exhibited his wonderful discovery "by which sounds may be transmitted through wires by "means of the electric current. By the invention of pe-"culiar apparatus, conversation may be carried on through "hundreds of miles of wires with the greatest ease."

The American Academy, at that meeting, passed a vote of thanks to Mr. Bell, who, though not a member, had been specially invited to explain his invention to them. 17

Jan. 13, 1877, Professor Bell gave a lecture on his electric speaking telephone, with an exhibition of it, before the Washington Philosophical Society, at Washington, D. C. This was reported in the Washington *Evening Star* of Jan. 20, 1877, and Mr. Bell was spoken of as the sole inventor.

Early in 1877, Professor Bell began to give public lectures and exhibitions of his electric speaking telephone.

He gave one in Salem, Mass., Feb. 12, 1877; and a report of it, published in the Boston *Globe* of Feb. 13, 18 was transmitted from Salem to Boston by his speaking telephone.

The lecture at Salem was followed by a series of lectures in Boston, Providence, Lowell, Manchester and New York, and these were extensively noticed in newspapers in different parts of the country: *e. g.*, the New York *Sun*, Feb. 11, 1877, had nearly a column about the lecture at

Salem; Boston *Journal of Chemistry*, March 1, 1877, had a long account; also the New York *Times; Daily Graphic* 19 of March 6, 1877, with illustrations; *Scientific American*, March 31, 1877, with illustrations; *Frank Leslie's*, March 31, 1877, with illustrations; *The Athenæum*, London, England, March 3, 1877.

Gov. Lippitt, of Rhode Island, introduced Mr. Bell to the audience on the occasion of his Providence lecture.

The lecture in New York, at Chickering's Hall, was preceded by the following request, the original of which is before me, was published in the daily papers, and will be produced if required.

20 "NEW YORK, April 7, 1877.

"Professor A. GRAHAM BELL, *Boston University:*

"*Dear Sir*, —The interest excited during the Centennial Exhibition by your experiments with your telephone, holding communications in audible speech with persons many miles away, and the published accounts of your improvements in the wonderful instrument, prompt us to request that you will deliver in our city, on some evening convenient to yourself, a lecture on sound and electricity, with an exhibition of your speaking telephone, showing 21 what can be done by it, and making known its scientific and commercial value.

"Very truly, etc.,

"F. A. P. BARNARD, *President Columbia College.*
"HOWARD CROSBY, *Chancellor of New York University.*
"HENRY MORTON, *Stevens Scientific School.*
"E. L. YOUMANS, *Ed. Popular Science Monthly.*
"CYRUS W. FIELD, *Atlantic Cable.*
"THOS. T. ECKERT, *Pres. Atlantic and Pacific Tel. Co.*
"A. M. MAYER, *Stevens Scientific School.*
22 "WILLIAM ORTON, *Pres. Western Union Tel. Co.*
"J. S. NEWBERRY, *School of Mines, Columbia College.*
"C. T. CHANDLER,
Prof. Chemistry, College Phys. and Surgeons.
"H. D. NOYES, *Prof. Aural Surgery, Bellevue College.*
"JNO. W. DRAPER, *Prof. Chemistry, N. Y. University.*"

The Boston lectures were preceded by the following, which was published in the daily papers, and will also be produced when required: —

"BOSTON, April 20, 1877.

"Professor ALEXANDER GRAHAM BELL: 23

"*Sir*, — The undersigned, having followed with great interest the accounts of your discoveries and inventions in connection with the electric telephone, which have from time to time appeared in the newspapers, and confident that the general public of the city in which your researches have been made will be glad to witness a practical exhibition of your telephone under your direction, respectfully request you to gratify this desire of your fellow-citizens at such time and place as may be most convenient to you.

"BENJAMIN PIERCE. 24
"JOSEPH LOVERING.
"E. N. HORSFORD.
"HENRY W. LONGFELLOW.
"GEO. B. EMERSON.
"O. W. HOLMES.
"CHARLES W. ELIOT.
"ALEXANDER H. RICE.
"NEHEMIAH GIBSON.
"FREDERICK O. PRINCE.
"WILLIAM F. WARREN. 25
"JOHN D. RUNKLE.
"C. F. ADAMS.
"WOLCOTT GIBBS.
"EDWARD C. PICKERING."

At Boston three lectures were given at the Music Hall, at the first of which Prof. Bell was introduced by Governor Gaston.

The New York *Sun*, the New York *Tribune*, the New
York *Herald*, the New York *World*, and the New York
Times, of May 12, 1877, had long accounts of an exhibi- 26
tion of the speaking telephone by Professor Bell in the

presence of General Eckert, president of the Atlantic and Pacific Telegraph Company, President Gibbs of the Dominion Telegraph Company, President Barnard and Professors Newberry and Rood of Columbia College, and many others, at the St. Denis Hotel.

The first New York lecture was given May 17, 1877, and long reports of it were in the New York *Herald*, *Tribune*, *World*, and *Times* of the next day. These reports
27 stated that President Barnard and Professor Rood of Columbia College, President Morton and Professor Mayer of the Stevens Institute, Mr. Cyrus W. Field, Mr. William Orton and General Eckert, and Messrs. Preece and Wheeler (of the English Postal Telegraph) were present, and that Mr. Field spoke through the telephone to the operator at Brunswick.

Dr. Henry Morton gave a lecture on the telephone, and an abstract of it is in the New York *Herald* of June 14, 1877.

28 The *Journal of the Telegraph*, March 1, April 1, April 16 and May 16, 1877, describe and refer to the electric speaking telephone, and to Mr. Bell as the inventor thereof.

In the early part of 1877, preparations were made to manufacture and supply electric speaking telephones for commercial purposes.

The Boston *Post* of April 5, 1877, states that a telephone line had been opened between the factory of Mr. Charles Williams, Jr., in Boston, and his house in Malden.

29 In May, 1877, a contract was made to supply them to the Cambridge Water Board.

In the same month, a set were furnished to Stone & Downer, bankers and brokers, of Boston, for regular use in their business, and agents were employed for various parts of the country; and their public and general commercial use, and the readiness of Mr. Bell's licensees to furnish them, was advertised and noticed in the papers: *e. g.*, New York *Graphic*, May 23, 1877; New York *Tribune*, Aug. 17, 1877; Cincinnati *Gazette*, Aug. 15, 1877; Cin-
30 cinnati *Enquirer*, Aug. 19, 1877.

About Aug. 1, 1877, Mr. Bell went to England to introduce the electric speaking telephone abroad. At that time there were about 1,000 in use under license from him; there were not any in use, so far as I know, or have ever heard, without license from him. All the publications on the subject had referred to him as the first and original inventor of the electric speaking telephone; and at that time I had not heard that any one claimed to have invented it before him, or to have transmitted articulate speech by electricity before he did. Up to this day I 31
have never heard of any claim publicly made by any one before August, 1877. I have not since then heard even of any alleged secret inventor of it before him, with the exception of the persons I will presently name.

Mr. Edward S. Renwick, called as an expert witness for the defence in the "Telephone Suits," testified (page 231).

"*Cross-Int.* 45. When did you first have any knowledge of the speaking telephone . . .?

"*Ans.* . . . The first knowledge I had was through printed descriptions. . . . It must have been in the year 32
1877. . . .

"*Cross-Int.* 46. Do you remember whether the first printed account of them which you read, spoke of them as a new invention, and did it attribute the invention of them to anybody?

"*Ans.* . . . My impression is that they spoke of the telephone as a new invention, and attributed it to Professor Bell."

Mr. Frank L. Pope, electrician, called as an expert witness for the defence in said suits, said that in the summer 33
of 1877, he saw used in Boston a pair of telephones which were identified as Bell telephones, made by Mr. Bell's licensees. They were in fact made under my supervision. Referring to that trial of them, he testified (page 340):

"*Cross-Int.* 41. Had you ever before that heard articulate speech transmitted over a telegraph wire by means of electricity?

"*Ans.* I had not.

"*Cross-Int.* 44. When did you first learn by actual 34 observation and study the interior construction of a speaking telephone?

"*Ans.* About the first of August, 1877.

"*Cross-Int.* 46. [The telephone you then examined] was made or purported to be made under the Bell patents, did it not?

"*Ans.* It was so marked and stamped."

Mr. Elisha Gray, examined as a witness for the defence in the same suit, testified (page 138) that he listened at the receiver of Mr. Bell's telephone when it was exhibited to 35 the judges at the Centennial, June 25, 1876, and heard words, and that it was the first time he had ever listened at a speaking telephone apparatus for the purpose of hearing what it would do."

The *Popular Science Review*, an English publication, for 1877, p. 429, has an article of four pages on electric speaking telephones, in which it refers to Gray as an inventor of the harmonic instrument, and Edison as the inventor of an important improvement, but attributes the main invention to Bell. It says: —

36 "THE TELEPHONE. — During the recent session of the "British Association at Plymouth, the lion's share of attention was unquestionably given to the telephone. Wherever the instrument was to be exhibited, whether in the "physical or in the mathematical sections, or at Mr. "Preece's popular evening lecture, there were always "crowded audiences, eager to learn something about so "novel an apparatus. At the *soirées*, too, the telephone "stood above everything else as the centre of attraction, "and knots of people were crowded round the instrument, 37 "anxious to converse with friends in distant apartments. "The interest in this subject culminated on the arrival of "Professor Graham Bell, the inventor of the talking telegraph."

The Mr. Preece referred to is, I presume, Mr. W. H. Preece, of the English Postal Telegraph, vice-president of the Society of Telegraph Engineers. A paper by him on the telephone was published in the *Philosophical Magazine* for April, 1878. It begins as follows: —

"The introduction of the speaking telephone, by Alexander Graham Bell, has supplied physicists with an instrument of research, as well as with an instrument of practical utility."

I have before me a pamphlet by Professor W. F. Barrett, F. R. S. E., read Nov. 19, 1877, before the Royal Dublin Society, and reprinted from their *Proceedings*. It says: —

"The various attempts to communicate audible speech by means of electricity have culminated in the recent discovery by Professor Graham Bell of the articulating telephone. The discovery was not the result of chance, but of long and patient endeavor. . . .

"These experiments revealed to Professor Bell the important point, that the transmission of speech by electricity could only be accomplished by using what may be termed an undulatory current; that is to say, one that merely varied in strength, without the occurrence of any actual interruptions which would give rise to a discontinuous or intermittent current. It is this principle of an unbroken current which distinguishes Bell's telephone from all preceding efforts.

"The electric currents in this telephone are in simple proportion to the motions of the air produced by the voice, and further, the electric waves sent to the distant extremity are (by a receiving arrangement precisely similar to the transmitting instrument) caused to reproduce motions of the air identically the same in character as those that gave birth to the currents. Thus, not only is articulation heard perfectly, but moreover, the different qualities of different voices are heard, so that at fifty or one hundred miles distance the individuality of the speaker is transmitted as well as his ideas."

I make the following statement as to the commercial use of electric speaking telephones, and as to the commercial recognition of Mr. Bell as the inventor, and as to the validity and controlling effect of his patents.

Nearly one hundred thousand electric speaking tele-
phones are now in use in the United States, under license
from the owners of Mr. Bell's two patents referred to in
the bill. Most of them have been manufactured by said
owners and stamped as made under said two patents,
42 and put out directly under written licenses which specially
acknowledge the validity of said two patents, and under
which the users pay royalties of from five dollars to ten
dollars a year on each instrument. The remainder have
been acquired or are being acquired from the Gold and
Stock Telegraph Company, and as fast as the work can be
performed, are likewise stamped and placed under the
same license and royalty. The licensees uniformly pay
their royalties, and I do not know of any case where any
of them have denied the validity of these patents.

43 The licensees and agents under said Bell patents have
originated the system of telephone exchanges. Such ex-
changes exist in more than two hundred and fifty cities and
towns in the United States. All of them are under such
licenses from and pay said royalty to the owners of said
patents, except in the case of three or four which have
telephones formerly furnished by the Gold and Stock Tele-
graph Company, and which are to submit and pay royalties,
but where the arrangements for this have not been fully
completed.

44 I am not aware of any public or known use of any elec-
tric speaking telephones whatever, at any time, without
paying royalty under said patents, other than those put out
by the Gold and Stock Telegraph Company, which I will
speak of hereinafter, and all of which have come or are now
coming under royalty and license; unless it be telephones
recently put out by A. K. Eaton, of which those com-
plained of in this suit are examples. We heard a few
weeks ago that he had made, or was about to make infring-
ing telephones, and our counsel were directed to bring a
45 suit as soon as the necessary proof of infringing use could
be obtained. It is only within a fortnight that we have
been able to obtain any telephones said to have been made
by him.

From time to time, a few infringing telephones have been found, but without mark or name to indicate their origin. The parties using them have uniformly, so far as I know, been notified to desist from using them, and have almost always done so at once. Where we have been able to trace the makers, suits have been brought, and further infringement stopped by decrees. It is practically very 46 difficult to discover and trace infringing telephones. They are so simple in construction that tolerably efficient instruments can be made by any mechanic; they can be used on private lines or on a person's own premises, so that it is almost impossible to find them; even when the users desist when notified, the expense of hunting for such infringements and tracing the instruments to their makers is great, and the makers when found are irresponsible persons, working secretly. Still I do not think that during the whole life of the patent, there have been as 47 many infringing telephones used, except by the Western Union Telegraph Company, as are often put out by us under license in a single day.

Mr. Bell's patent 174,465 of March 7, 1876, was the first patent ever granted which claimed or showed an apparatus intended for the transmission of vocal sounds. During the first year after that patent none were granted which purported to relate to the subject, except patent 186,787, to Mr. Bell. During the second year only three were granted, of which one was to me, and one to Mr. Berliner, 48 for improvements relating to telephones. Since then more than a hundred have been granted for improvements in electric speaking telephones, and nearly as many in other appliances intended for use with telephones.

In the autumn of 1877, and after Mr. Bell had gone abroad, we heard that the Western Union Telegraph Company and its associates were satisfied of the great commercial value of the telephone to the public and to their own telegraphic interests, and that they were preparing to make and use telephones so soon as they could make the arrange- 49 ments they thought needful for the purpose.

With this view, as I understood, they formed, about Dec. 1, 1877, a corporation called the "American Speaking Telephone Company." Their advertisements stated that they owned the inventions of Edison, Gray, Dolbear and others, and the list of directors included the president and principal officers of the Western Union and Gold and Stock Telegraph Companies. It was not, however, until about the summer of 1878 that they began to put out telephones
50 to any serious extent.

Mr. **Frank L. Pope**, the electrical expert of the Western Union Telegraph Company, was called by the defendant in the suit of Bell Telephone Company *v.* Dowd, and testified as follows in his third and fourth answers, pages 319, 320: —

"Some time during the summer [of 1877], being in Boston on business, I saw and talked through a speaking telephone for the first time, and within a short time thereafter, which was in the month of August, 1877, I was
51 directed by Mr. Orton, then president of the Western Union Company, to make a thorough investigation of the whole subject, as far as practicable. I accordingly made such an investigation, and from that time until the present have endeavored to inform myself as completely as possible of everything in relation to the subject of speaking telephones.

"The directions which were given me by President Orton were, to the best of my recollection, entirely verbal. I had before mentioned to him the fact of my having seen
52 and talked through a telephone in Boston (I suppose it to have been a Bell telephone); and it was some days after I had mentioned this to him that he sent for me, and said to me in substance, — I do not pretend to give his exact words, — 'I have been looking into this matter of the telephone somewhat, and regard it as a matter likely to be of considerable future importance. If this proves to be the case, it is very necessary that we should have the right to use it; therefore I wish you to make a careful and thorough investigation of the whole subject and ascertain

what are the fundamental principles of the invention, and 53
what inventions or patents it will be desirable or necessary for us to acquire the control of, in order to be able to use the invention in connection with our business.' I accordingly set about this investigation, and was engaged in it for two or three months, all the time I could spare from my other duties."

Suits were brought under Mr. Bell's said two patents against those who used the telephones of said infringing associated corporations, and one of them, Bell Telephone
Company *et al. v.* Peter A. Dowd, in the United States Cir- 54
cuit Court at Boston, was vigorously pushed for trial. That suit was defended by the Western Union Telegraph Company and its associates, and the counsel for the defendant were Mr. George Gifford, Mr. Causten Browne and Mr. W. D. Baldwin; Mr. Edward S. Renwick and Mr. Frank L. Pope testified as experts for the defence.

The defendant set up that Mr. Bell was not the first inventor, and to anticipate one or more of his claims he named three persons as prior inventors, viz., Elisha
Gray, Thomas A. Edison and Amos E. Dolbear. It 55
has appeared that the American Speaking Telephone Company owned all the telephonic inventions of these three persons. Evidence in chief for the complainants was taken and completed; evidence for the defence was taken and completed; evidence for the complainants in reply was taken and completed: the whole forming about 1,200 printed pages, a copy of which is herewith filed. After this it was agreed that all the telephones used by the defendant and put out by the Western Union and Gold and
Stock Telegraph Companies and their associates should be 56
sold to the Bell Telephone Company at less than cost, should be put under license from the Bell company under the Bell patents, for which the established and usual royalties should be paid, and that the corporations defending the suit should retire from the business of manufacturing telephones and should not use any telephones except those to be obtained from the Bell Telephone Company, for all of

which they should pay the usual and established royalties to the Bell Telephone Company. It was further agreed
57 that the Bell company should have an exclusive license for electric speaking telephones and their appliances, under all patents applicable thereto which the said associated corporations owned or controlled.

In consideration of this, those other companies were to receive one fifth part of the royalties collected by the Bell Telephone Company on electric speaking telephones.

It was understood by me, and I heard from others at the time, that the result of the evidence had satisfied the counsel for the defence that Mr. Bell was the first and
58 original inventor of the electric speaking telephone, and that the settlement was based upon that belief. The Bell Telephone Company was satisfied that the evidence sustained fully Mr. Bell's claims, and was led to make the arrangement mentioned for the purpose of avoiding protracted and expensive litigation, and because of the immediate pecuniary advantages which it offered, and because the Bell company desired an unquestionable license under certain patents and inventions controlled by their opponents. One of these patents, on which suit had been
59 brought against the Bell company and those using instruments furnished by it, was the Page patent, since sustained by his Honor Judge Blatchford, in the United States Circuit Court for the Southern District of New York.

The result of that settlement has been that all the telephones formerly put out by the opponents of the Bell company, amounting to upwards of 30,000, are now paying royalty to it under license from it, except in the case of a certain number, the transfers and licenses for which have not been fully completed, but are in progress. More
60 than two hundred and fifty cities and towns in the United States have telephone exchanges, and regular organizations are engaged in furnishing to the public speaking telephones under license contracts. With the two or three exceptions referred to, every telephone exchange in the United States and every organization publicly supplying telephones does

so under licenses from the Bell Telephone Company which expressly acknowledge the validity of the said two Bell patents, and under which they pay yearly royalties to the Bell Telephone Company, owners of those patents. Among the more prominent of these I will mention the Metropoli- 61
tan Telephone and Telegraph Company, licensee of the Bell Telephone Company, and under whom all telephones within thirty-three miles of New York City Hall, and in the whole of Long Island are sublicensed, and to whom royalties on them are paid. I am not aware of any exception to this within said territory (other than a few which have licenses direct from the Bell Telephone Company), except those by the defendants and a few others the makers and users of which we have been unable to discover. 62

As preliminary to the said contest between the Bell Telephone Company and the Western Union Telegraph Company and its associates, the latter acquired all the inventions relating to speaking telephones made by Mr. Elisha Gray, Mr. T. A. Edison and Mr. A. E. Dolbear, and caused said three persons to make applications for patents at the Patent Office; and these and other applications have led to a very large number of interferences, in which some of the thirteen claims of said two patents of Bell are involved. Only one of them — viz., that known as 63
Interference A — involves the broad claim to the invention of the speaking telephone. The parties to this interference, at the time of the said settlement, were Messrs. Bell, Edison, Berliner, Gray and Dolbear. Mr. George B. Richmond and Mr. Holcombe had been parties to it; but by decisions of the Patent Office, May 1, 1879, and July 29, 1879, the claims of the last two to priority were disallowed, and from this decision no appeal was taken.

The inventions of Mr. Berliner are owned by the Bell Telephone Company. His preliminary statement, filed in 64
the Patent Office by him under oath, states that he did not direct his attention to speaking telephones until more than nine months after the date of Mr. Bell's first patent, and

after he well knew of it. His claim, in fact and as set forth in his application, is that he is the first inventor of a certain improved means of varying the resistance of an electrical circuit in order to accomplish the purposes which Mr. Bell's patent No. 174,465 says can be accomplished by varying this resistance, and for the ultimate purpose of
65 transmitting sounds by the method referred to in the fifth claim of said Bell patent.

The inventions of Messrs. Edison, Gray and Dolbear were owned by the Western Union Telegraph Company and their associates at the time of the suit Bell Telephone Company *v.* Dowd, already mentioned, and as their applications with broad claims were pending in the Patent Office, the overthrow of Mr. Bell's patent upon prior inventions of either of those gentlemen would have given the Western Union Telegraph Company and their associates
66 the ownership of the speaking telephone. But they did not suffice to enable the defendants to prevail in those suits. The reasons why they could not will appear from the dates proved by Mr. Bell (which are stated in his affidavit in this case), when compared with the statements made by those inventors, among which are the following: —

Mr. Elisha Gray claims to be the first inventor of certain devices which do not of themselves constitute a speaking telephone, but which are said to be used in
67 speaking telephones. I do not understand that the origin of these devices is material in the present case; the American Bell Telephone Company has, however, the exclusive right to use them in electric speaking telephones.

The only claim ever made for him as the first inventor of the speaking telephone rests upon a caveat filed Feb. 14, 1876. He testified in the "Telephone Suits": —

"*Int.* 50. At the time of your filing your caveat, Feb. 14, 1876, had you ever seen or heard of any apparatus for the telephonic transmission of articulate speech other than
68 that which you described and represented in that caveat?

"*Ans.* I had not."

His testimony, and that of his assistant, Mr. Goodridge,
do not give for the conception contained in that caveat any
date earlier than Feb. 11, 1876, when he made a sketch
of it and explained it to Mr. Goodridge (Goodridge, ans.
37, page 18, Interference Record). The suggestion which
led to this conception came from a "Lover's Telegraph"
or string telephone, which his assistant testifies was first
shown him "in December, 1875" (ans. 96, page 71; ans.
172, page 108). Mr. Gray knew of Mr. Bell's patent 69
174,465 in March, 1876 (cross-ans. 103, page 137, "Telephone Suits"). He exhibited at the Centennial his harmonic
multiple telegraph inventions, and displayed them to the
Emperor of Brazil and a distinguished group of judges,
including Sir William Thompson and Professor Henry,
on June 25, 1876; immediately afterwards Mr. Bell made
the memorable exhibition of his electric speaking telephone
to the same persons, and Mr. Gray was one of those who
took part in it and listened at Mr. Bell's receiver. Mr.
Gray so testifies (cross-ans. 105-108, page 138, "Telephone 70
Suits"). He also testified:—

"*Int.* 56. Was this apparatus which you saw at the Centennial the first one you ever saw in which an induction diaphragm was used in combination with an electromagnet as a telephone transmitter?

"*Ans.* It was.

"*Int.* 57. Was such a combination for the purpose of a telephone transmitter new with Professor Bell, so far as you know?

"*Ans.* It was, so far as I know:" 71

This combination constitutes the magneto-telephone transmitter.

After this, for the first time, he attempted to make a speaking telephone transmitter, and constructed one in accordance with his caveat, but did not succeed in transmitting speech by it. (Mr. Gray's ans. 12, page 45 of Interference Record).

In connection with these dates of Mr. Gray's invention, as stated by himself and his assistant, Mr. Goodridge, on

72 the witness stand, I am requested to mention that it is apparent on the face of Mr. Bell's patent, 174,465, that the copy of the specification filed was completed and signed on or before Jan. 20, 1876, and was filed Feb. 14, 1876; and I constructed an electric speaking telephone, for Mr. Bell, and according to his direction in June, 1875.

In February, 1877, Mr. Gray delivered a lecture on telephony in McCormick Hall, Chicago. Before doing so he wrote to Professor Bell saying that he proposed to explain his own (Gray's) system of musical or harmonic telephony,
73 but would like, with Mr. Bell's permission, "to explain and exhibit your method of transmitting vocal sounds as well, but do not feel at liberty to do more without permission from you. I should explain it as your method and not mine, though the Office records show a description of the talking telegraph filed by me the same day yours was filed. The description is substantially the same as yours." Mr. Bell answered that he might do so if he would refute some remarks in a Chicago paper which seemed injurious to Mr. Bell's claims as the sole inventor. Mr.
74 Gray replied: —

"I found the article I suppose you refer to in the personal column of the *Tribune*, and am free to say it does you injustice. I gave you full credit for the talking feature of the telephone, as you may have seen in the Associated Press despatch that was sent to all the papers in the country, in my lecture in McCormick Hall, Feb. 27. There were four different papers represented at the lecture, but only one — the *Tribune* — alluded to my mention of you except the 'Press' despatch. I described your apparatus at length by diagram.
75

"Of course you have had no means of knowing what I had done in the matter of transmitting vocal sounds. When, however, you see the specifications, you will see that the fundamental principles are contained therein. I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been *reduced* to *practice* in the *strict sense* of that phrase should be dignified with the name 'invention.'

"Yours very truly,

"ELISHA GRAY." 76

A report of that lecture in the Chicago *Tribune*, and testified to by Mr. Gray as substantially correct (ans. 136, page 146), showed that after Mr. Gray had completed the description of his own inventions in harmonic telegraphy, he referred to the speaking telephone and attributed the invention of it to Mr. Bell. The report says:—

"Another development of the telephone was interesting in a scientific point of view. Professor Bell, in his investigations, had gone a step beyond composite tones, although they were embraced in it and developed the transmission 77 of vocal sounds."—"Telephone Suits," page 177.

April 2, 1877, and while Mr. Bell was engaged in lecturing on his speaking telephone, Mr. Gray lectured in New York on his own harmonic telephone, and in that lecture he said substantially as is reported in the New York *Tribune* of the following day, viz.:—

"After the first part of the programme had been executed, Mr. Elisha Gray came forward and addressed the audience. He was aware that great confusion existed in the popular mind as to what this telephone could perform; 78 in particular, it had been confounded with the speaking telephone invented by Professor A. Graham Bell, of Boston. Professor Bell, Mr. Gray said, was present in the audience."—"Telephone Suits," page 156.

I was at this time engaged with Mr. Bell, and knew of these occurrences and these letters. These letters and reports of lectures will be found as parts of Mr. Gray's cross examination in the "Telephone Suits." I never heard that Mr. Gray was, or was to be, put forward as the first inventor of the electric speaking telephone, until after and in connec- 79 tion with the attempt of the Western Union Telegraph Company to manufacture and use telephones, as I have stated, and after they had acquired the control of all his inventions relating to electric speaking telephones. His application for a patent was filed Oct. 27, 1877, more than twenty months after the grant of Mr. Bell's first patent, nine months after the grant of his second one, and at a time when we had several thousand telephones in use under license and paying royalty.

80 Mr. Dolbear was examined as a witness in the telephone suits. He testified (p. 286): —

"*Int.* 4. When did you first turn your attention to the subject of the speaking telephone, and when did you first make a record of the results of your thought upon that subject?

"*Ans.* My first attention to the telephone that I have any memory of now was in August, 1876, at which time I made some experiments bearing upon that subject."

He testified that he had made previously some experi-
81 ments as to the transmission of sound, but says as to them (p. 287), "The result was that the sounds transmitted were only those of the pitch of the voice, and not articulate speech."

Feb. 16, 1877, he wrote to Professor Bell the following ("Telephone Suits," p. 299): —

"Professor A. G. Bell:

"*Dear Sir,* — The other day I visited your room at Exeter Place, and was kindly shown your invention, the telephone, by Mr. Watson. . . . I congratulate you, sir,
82 upon your very great invention, and I hope to see it supplant all forms of existing telegraphs, and that you will be successful in obtaining the wealth and the honor which is your due.

"Yours truly,

"A. E. Dolbear."

I am the Mr. Watson referred to in the letter. Professor Dolbear did not then nor at any time claim to be an inventor of the speaking telephone. The only claim which he has made, and the claim set forth in his application filed
83 in the Patent Office, Oct. 29, 1879, after he had sold his

inventions to the Gold and Stock Telegraph Company, was to certain improvements shown in Mr. Bell's second patent 186,787, of Jan. 30, 1877; viz., the use of a permanent magnet. That this is the whole claim he has ever made is explicitly stated in his sixty-fourth and sixty-fifth cross answers, p. 300, in which he limits his claim to the improvement set forth in the eighth claim of Mr. Bell's said patent 186,787.

In his deposition (ans. 4) and in his preliminary statement he gives the date of the conception of this as Sept. 20, 84
1876, and says that the instrument which first embodied it was completed and first tried in "the last part of January or first part of February, 1877." This invention was described by Mr. Bell in a specification prepared in the United States and filed in the English Patent Office, Dec. 9, 1876. It is a matter within my personal knowledge that a permanent magnet telephone was made for Mr. Bell, and in accordance with his invention, in July, 1876. I used it with Mr. Bell to transmit speech between Boston and Cambridge, in October or November, 1876, and I believe that he had used 85
it before that.

A metallic diaphragm for a receiver was used in the instrument of Mr. Bell, at the Centennial, in June, 1876. This receiver was the one used by the judges and Mr. Gray, June 25, 1876, and is described in the judges' report.

A metallic diaphragm for a transmitter was made by me for Mr. Bell under his directions, in June, 1876, and used by me, with him, as a transmitter for articulate speech, about the first of July, 1876. All the features of Mr. 86
Bell's patent of Jan. 30, 1877, No. 186,787, were described in his English patent, No. 4,765, the completed specification of which was filed in the English Patent Office Dec. 9, 1876.

Mr. Edison's telephonic inventions were owned by the Western Union Telegraph Company and the American Speaking Telephone Company at the time said corporations defended said suit, and his name was mentioned in the answer as one who was the first inventor of something 87 covered by some of Mr. Bell's thirteen claims. I understood that the practical recognition of Mr. Bell as the first inventor of the electric speaking telephone, which was involved in the submission to the claim made by the complainants, was based upon the knowledge that nothing he had done could antedate Mr. Bell's said invention.

In 1878, and during the contest between the Bell Company and the Western Union and Gold and Stock Telegraph Companies, Mr. George B. Prescott, electrician of the Western Union Telegraph Company, vice-president of 88 the Gold and Stock Telegraph Company, and director of the American Speaking Telephone Company, published the first edition of a book called "The Speaking Telephone," etc., and in 1879 he published a second edition of it. Chapter VI. of that book is entitled "Edison's Telephonic Researches," and begins as follows (p. 218) : —

"The following communication from Mr. Thomas A. Edison gives a detailed account of his researches in telephony, and is a valuable contribution to the history of the speaking telephone :—

89 "'Some time in or about the month of July, 1875, I began experimenting with a system of multiple telegraphy which had for its basis the transmission of acoustic vibrations. Being furnished at the same time by Hon. William Orton, president of the Western Union Telegraph Company, with a translated description from a foreign scientific journal of Reis's telephone, I also began a series of experiments with the view of producing an articulating telephone, carrying on both series simultaneously by the aid of my two assistants, Messrs. Batchelor and Adams.' "

90 It is not stated expressly whether Mr. Edison did or did not invent or construct a speaking telephone before the date of Mr. Bell's patent; but I understand from the foregoing extract that it was not until in or about July, 1875, that he turned his attention to the subject. The dates already given show that Mr. Bell had preceded this. It appears from statements made on page 223 of the same communica-

tion that the form of transmitter with which Mr. Edison's name is chiefly or solely connected was first devised by him in 1877.

In December, 1879, Mr. William L. Voelker, of Morton, 91 Pa., was put into interference with Mr. Bell, upon an application filed in the Patent Office May 19, 1879, nearly three years after Mr. Bell's public exhibition at the Centennial, and at a time when there were more than 30,000 telephones in use paying royalty to Mr. Bell's assignees.

Mr. Voelker's preliminary statement says that he commenced his experiments on telephones about Christmas, 1875, and completed his first telephone in March, 1876. In his deposition (p. 19) he says, "I conceived the idea which is the point of this controversy during the month 92 of January, 1876. I carried it into practical shape the latter part of February or beginning of March of the same year."

Mr. Bell's patent shows that his completed specification was signed Jan. 20, 1876, and filed Feb. 14, 1876.

If the instrument constructed by Voelker were a speaking telephone, the dates he names would not anticipate Mr. Bell.

The manufacture of the instruments made under license from Mr. Bell has been under my personal supervision. 93 The Bell company has taken extreme pains to construct them of the best forms, and with all the improvements best suited to practically carry out the method set forth in the fifth claim of Mr. Bell's patent 174,465, and have made a very large number of experiments for this purpose. They have followed with great success the line of improvement marked out by Mr. Bell in his patent No. 186,787, of Jan. 30, 1877; that is to say, they use a diaphragm of inductive metal, an electro-magnet with a short coil surrounding a small, soft iron core, permanently magnetized 94 by induction from a compound permanent magnet to which it is fastened. They surround the diaphragm with a case which encloses the rear part, and leaves in front a narrow and thin air space, with a hole in the centre to speak into or listen at. Most of the telephones used in England and some other foreign countries are made in Boston under my supervision.

One of the most important improvements introduced is a "variable resistance" "battery telephone" or "voltaic
95 transmitter," which produces on the line wire and in the receiver electrical undulations corresponding in form to the sound waves produced by the voice of the speaker, and does this by utilizing the movement given to the transmitting diaphragm by those waves, to vary the resistance of a circuit exterior to a battery which supplies it with a constant electro-motive force.

The form of battery transmitter most in use was devised by Mr. Francis Blake, Jr., and is known as the "Blake transmitter." Mr. Blake was an officer on the United States Coast
96 Survey, and in charge of the electrical determination of longitudes. After he had invented this instrument, he recognized that its use was covered by Mr. Bell's first patent, the validity of which he also recognized; and he brought it to the Bell company, disposed of it to them, and has since become a director of the company. It is one of the class that operate to vary the resistance of a battery circuit by the variations of resistance due to variations of pressure between two electrodes constantly in contact, one of which is acted upon by the diaphragm vibrated
97 by sound waves, while the other, carried on a weighted spring, acts as an anvil.

More than 35,000 of them have been made, licensed and put out under full royalty by the Bell company. They are all licensed under the said Bell patents, are marked as made under said patents, and are universally recognized and paid for as coming under said Bell patents.

The various forms of voltaic transmitting telephones, of which the Blake is the one most practically efficient, have
98 always been recognized as coming under and as covered by Mr. Bell's said patent, 174,465. I will mention some instances of such recognition, in addition to Mr. Blake's action.

Among the interferences formerly declared by the Patent Office, the first one, known as "A," set forth as the issue, in substance, the electrical transmission of articulate speech by causing electrical undulations on the line wire corresponding to the sound waves in their character as well as in their frequency or pitch. As contestants the Office named Mr. Bell, referring to the fifth claim of said 99 patent and to Gray, Edison, Holcombe, Berliner and Voelker, whose applications described and showed battery or voltaic transmitters alone.

In said suit against Dowd the only inventions and apparatus set up to antedate Mr. Bell's said claim were battery transmitters. The transmitters most in use are of this character. More than 12,000 of the transmitters in use by and under the Western Union Telegraph Company and its associates at the conclusion of said suit were battery transmitters with hard electrodes in contact, using no 100 liquid, and of the form known as Edison carbon transmitters. In the settlements which I have referred to, these have all been treated as coming under said Bell patent, and transfers have been made, licenses taken and royalties paid accordingly.

I have examined the telephones, complainants' Exhibit Eaton Magneto Telephone and complainants' Exhibit Eaton Battery Telephone. When connected up and in operation, they will operate according to the method set forth in Mr. Bell's specification 174,465 and referred to in 101 the fifth claim thereof, and will thereby transmit articulate speech. The battery telephone is intended to be used as a transmitter, and when so used the motion given to its diaphragm by the voice of the speaker operates to cause the desired electrical undulations; it does this in one of the ways mentioned in the specification, viz., by varying the resistance of the circuit by the motion of one electrode. The Eaton magneto telephone, in its operation, its principle and in the combination of its parts, copies that portion of Mr. Bell's said apparatus which is particularly shown in 102 Fig. 7 of said patent; both also adopt improvements shown

and claimed in Mr. Bell's patent 184,787, viz., the metallic diaphragm and the sound box or inclosing case. The Eaton magneto telephone also adopts other improvements set forth in said Bell patent 184,787, viz., the permanently magnetized core with the coil wound on the end of it; and it uses what is intended for a quick-working magnet, though not of the precise form shown by Mr. Bell. The part of the Eaton magnet enclosed within the coil is made
103 of a bundle of wires; and this, before the date of Mr. Bell's said patent, was well known as a device for avoiding magnetic inertia.

Sworn to. THOMAS A. WATSON.

AFFIDAVIT OF THOMAS A. WATSON.

[FILED OCT. 10, 1881.]

Thomas A. Watson, a witness of lawful age, having been duly sworn, doth depose as follows: —

My name is Thomas A. Watson; age, twenty-six; residence, Everett, Mass. I am general inspector of the American Bell Telephone Company, and in that capacity or otherwise have been connected with the manufacture and use of electric speaking telephones, under Mr. Bell's patents, from the time when they first began to be manufactured or exhibited. Patent dated March 7, 1876, was, I verily believe, the first published description of any apparatus intended for, and capable of, transmitting vocal utterances telegraphically.

May 10, 1876, a description by Professor Bell of his researches in telephony was read before the American Academy of Arts and Sciences, at Boston. This paper was published soon afterwards, and contained a description of his electrical speaking telephone, as shown in Fig. 7 of said patent, and described the transmission of speech by it. It also contained a description of an electrical speaking telephone made upon the plan of varying the resistance of an electrical circuit supplied with a constant electro-motive force from a battery; the particular form indicated was that known as the liquid transmitter, referred to in said specification, and was described as follows: —

> "A platinum wire, attached to a stretched membrane, completed a voltaic circuit by dipping into water. Upon speaking to the membrane, articulate sounds proceeded from the telephone in the distant room. The sounds produced by the telephone became louder when dilute sulphuric acid or a saturated solution of salt was substituted for the water. Audible effects were also produced by the vibration of plumbago in mercury, in a solution of bichromate of potash, in salt and water, in dilute sulphuric acid, and in pure water."

This was published in volume twelve of their Proceedings before the judges of the group and many other persons.

Two sets of Professor Bell's speaking telephones were made by me for exhibition at the Centennial Exhibition in Philadelphia, and were exhibited there in June, 1876. They consisted of a "magneto" transmitter and receiver, and of a liquid transmitter. I saw them there on exhibition.

I annex drawings of those instruments, marked "Complainants' Exhibits 2, 3, 4, 5."

The depositions of Mr. A. G. Bell and of Mr. William Hubbard and of Mr. Elisha Gray, in the suit Bell Telephone Company *v.* Dowd, in the United States Circuit Court for the District of Massachusetts, describe one public exhibition of the transmission of articulate speech by them, on June 25, 1876.

Two reports were made upon Mr. Bell's said exhibit. One, by Professor JOSEPH HENRY, in "General Report of Judges of Centennial Exhibition, Group XXV.," pages 20 and 21, describes the apparatus and transmission of speech by it, and says, "This telephone was exhibited in operation at the Centennial Exhibition, and was considered by the judges the greatest marvel hitherto achieved by the telegraph." Its invention was, by that report, attributed to Mr. Bell.

The other report was made by Sir WILLIAM THOMSON, and is found in "Reports on Awards, Group XXV, Centennial Exhibition," pages 130, 131. It contains the following: "Mr. Graham Bell exhibits apparatus by which he has achieved a result of transcendent scientific interest, — the transmission of spoken words by electric currents through a telegraph wire. To obtain this result, or even to make a first step towards it, — the transmission of different qualities of sound, such as the vowel sound, — Mr. Bell perceived that he must produce a variation of strength of current in the telegraph wire as nearly as may be in exact proportion to the velocity of a particle of air moved by the sound; and he invented a method of doing so . . . which has proved perfectly successful." The report then proceeds to describe the magneto-telephone and the transmission of whole sentences by it, and continues: "I need scarcely say I was astonished and delighted; so were others, including some other judges of our group, who witnessed the experiments, and verified with their own ears the electric transmission of speech. Thi s, perhaps the greatest marvel hitherto achieved by the electric telegraph, has been obtained by appliances of quite a homespun and rudimentary character."

The judges were: Joseph Henry, J. E. Hilgard, James C. Watson, H. K. Oliver, F. A. P. Barnard, J. Schudmayer, E. Levasseur, P. F. Kupka, Ed. Favre-Perret, Chas. E. Emery.

This apparatus, and the transmission of speech by it, were noticed generally in the newspapers, and the invention attributed exclusively to Prof. Bell. I instance the *Scientific American* of Sept. 9, 1876, the *Boston Transcript* of July 8, 1876, and the New York *Evening Post* of Sept. 5, 1876.

The Boston *Evening Transcript* of July 8, 1876, contains the following: —

> *Notes at the Centennial.* — ". . . Prof. Bell has also a telegraphic and telephonic apparatus in this department for the transmission of many messages over a singe wire, and of musical and articulate sounds by telegraph. The experiments which have been made in the presence of the Emperor of Brazil, Sir William Thomson, and others interested in the subject, have been highly interesting and satisfactory in their results."

The New York *Evening Post* of Sept. 5, 1876, contains the following: —

> "Yet the telegraphic and telephonic apparatus invented by A. Graham Bell should reconcile us to this loss. . . . Prof. Bell has sent a valuable collection that well illustrates the mode by which many messages may be transmitted over a single wire, and also the ease with which musical and articulate sounds may be transmitted by telegraph. . . . Spoken words may be thus transmitted."

Boston *Daily Advertiser* of Sept. 25, 1876, says: —

> "The following passage, taken from the opening address of Prof. Sir William Thomson, on assuming the chair of the section of physical science at the Glasgow meeting of the British Association, will be read with interest, as showing the impression made upon an English student of science, by our progress in discovery and in practical science; 'In the Canadian department, I heard, "To be or not to be," "there's the rub," through an electric telegraph wire; but, scorning monosyllables, the electric articulation rose to higher flights, and gave me passages taken at random from the New York newspapers: "S. S. Cox has arrived" (I failed to make out the "S. S. Cox"), "The City of New York," "Senator Morton," "The Senate has resolved to print a thousand extra copies," "The Americans in

London have resolved to celebrate the coming Fourth of July." All this my own ears heard, spoken to me with unmistakable distinctness by the thin circular disk armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Prof. Watson, at the far end of the line, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform, in the neighborhood of an electro-magnet in circuit with the line, motions proportional to the sonorific motion of the air.

" 'This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realize the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously, and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sounds?' "

The Boston *Daily Advertiser* of Oct. 16, 1876, says: —

"At a meeting of the American Academy on Wednesday evening, Prof. Bell exhibited his wonderful discovery by which sounds may be transmitted through wires, by means of the electric current. By the invention of peculiar apparatus, conversation may be carried on through hundreds of miles of wires with the greatest ease."

The *Scientific American* of Sept. 9, 1876, contained the following: —

"THE HUMAN VOICE TRANSMITTED BY TELEGRAPH.

"Several weeks ago we gave a sketch and description of the thread telegraph, consisting of two small tin or wooden cylinders, each having a membrane stretched over one end, the two membranes connected by a stout thread. Two persons may readily communicate the sounds of the voice by means of these instruments over a thread fifty or a hundred feet in length. The person sending speaks within one of the cylinders, which causes the membrane to vibrate; the vibration passes along the stretched thread to the membrane of the other cylinder, which being held to the ear of the person receiving the message, the vibration is duly heard, or, in other words, the voice of the sender is made audible.

"Professor Graham Bell, by a device somewhat analogous, has succeeded in transmitting the tones of the human voice by telegraph. Instead of the thread, he connects the membranes of the two cylinders or drums with the armatures of the electro-magnets, one drum being placed at each end of the telegraph wire. In fact, he not long ago demonstrated the possibility of conveying vocal sounds by means of the ordinary telegraph wires and special appliances for transmitting and receiving the sounds. The apparatus used by Professor Bell is thus described: Two single-pole electro-magnets, each having a resistance ten ohms, were arranged in circuit with a battery of five carbon elements, the total resistance being about twenty-five ohms. A drumhead of gold-beater's skin. about two and three fourths inches in diameter, was placed in front of each electro-magnet, and a circular piece of clock-spring was glued to the middle of the membrane of each drumhead. One of these telephones was placed in the experimental room, and the other in the basement of an adjoining house. Upon singing into the telephone the sounds of the voice were reproduced by the instrument in the distant room; and if two persons sang simultaneously, the two notes were audible at the other telephone.

"At the time of the lecture, an experiment was made to show the transmission of articulate speech, an assistant going into the adjoining building, where one of the telephones was placed. Several familiar questions were, it is said, understood after a few repetitions. The vowel sounds alone are those faithfully reproduced. Diphthongal sounds and rotund vowels are readily distinguished, but consonants are generally unrecognizable. Now and then, however, a sentence comes out with almost startling distinctness, the consonants as well as the vowels being clearly audible. Professor Bell stated that telephonic effects can be produced with three varieties of currents,— the intermittent, the pulsatory and the undulatory. The first are characterized by the alternate presence and absence of electricity in the circuit, the pulsatory current by sudden changes in intensity, while undulatory currents are obtained by gradual changes analogous to the changes of density of air produced by vibrations of a pendulum.

"The most recent trial of Professor Bell's instrument was at his residence, Brantford, Canada, Aug. 11. The Toronto *Globe* states that the instruments were placed, one in the porch of the residence, and the other in an out-house on the grounds, and communication between these made by ten miles of wire. Musical notes, the human voice, and songs spoken and sung before one instrument were plainly audible by placing the instrument to the ear at the other. By this invention, too, any number of messages can be conveyed over one wire in either direction, provided they have a different pitch; the tones of the voice can pass over the electric wire, enabling the hearer at any distance to hear distinctly what is said, and to distinguish the voice of the speaker. On Aug. 10, the professor had communication made with his instrument on the common telegraph wire beween Brantford and Mount Pleasant (five miles), and was spoken with, while in Mount Pleasant, by Professor D. C. Bell and Mr. Griffin from the *Dominion* office in Brantford. On the evening of Aug. 12, the professor tried a new experiment, having had an instrument made, so that three persons could sing different tunes, or different parts of the same tune, into the instrument at the same time. The trial was perfectly successful, the different voices coming distinctly over the wire at the same time, so that they could be separately distinguished by the listener. The practical exemplification of the lately discovered system of telephony made by the professor afforded much pleasure and information to those present."

The Boston *Evening Transcript* of Oct. 19, 1876, says: —

"*Telephony*. . . . The registry of sounds by telegraph has now been carried to such a point that the delicate variations involved in the articulation of human speech are transmitted with such unerring accuracy and distinctness that one may talk with another through the telegraph as though face to face.

"The leading scientific men of the world gathered at Philadelphia last summer saw the fact accomplished on a small experimental scale. Sir W. Thomson was so impressed that in his opening address as president of the British Association he described it at some length, and pronounced it the greatest by far of all the marvels of the electric telegraph. Ten days ago the test was repeated over an actual out-of-door telegraph between this city and Cambridge. The entire success of this experiment marks, for all that we can see, a revolution and advance in the world's progress worthy to rank with the practical completion of the first printing telegraph in New York City about forty years ago, and with the laying of the great ocean cables twenty years ago.

"The operation of this new and startling development of telegraphic mechanism is thus described by Professor Thomson, in the address referred to: —

"'All this my own ear heard spoken to me with unmistakable distinctness by the thin, circular disk armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Prof. Watson, at the far end of the line, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform, in the neighborhood of an electro-magnet in circuit with the line, motions proportional to the sonorific motions of the air.'. . . .

"We give in another column the interesting account of the practical exemplification of the invention between Boston and Cambridge. The inventor, Mr. Graham Bell, is a young Edinburgh scientist, formerly of Montreal, but later of this city, and a naturalized citizen of the United States."

During the fall of 1876 and the following winter and spring, Mr. Bell operated publicly his electric speaking telephone. I assisted at most or all of these exhibitions. They were noticed very generally in the newspapers as matters of practical value. I mention: —

Boston *Post*, Oct. 20, 1876.

Boston *Daily Evening Traveller*, Oct. 19, 1876.

Boston *Sunday Herald*, Oct. 22, 1876.

Titusville *Herald*, Oct. 22, 1876.

Boston *Evening Transcript*, Oct. 19, 1876.

These described the transmission of speech form Boston to Cambridge.

The New York *Tribune* of Monday, Oct. 23, 1876, has the following: —

> "The experiments which Professor A. Graham Bell has been recently making, relative to the transmission of speech by wire, have been quite successful. Two operators were stationed two miles apart, one in Boston and the other in Cambridge. The battery ordinarily used was replaced by one of ten carbon elements. At first the sounds were indistinct, but soon they grew clear and intelligible. The operators carried on a long conversation, and on subsequently comparing their records ascertained that the tones had been transmitted with perfect accuracy."

An editorial in the *New York Tribune* of Nov. 9, 1876, contained the following: —

> "The Centennial Exhibition has afforded the opportunity to bring into public view many inventions and improvements which otherwise would only have been known to the smaller circles that may find them of service. . . . The telephone is a new instrument of electrical science, more likely than some of the rest to find immediate use. It operates by transmitting the current through a tuning fork. The fork will only vibrate a given number of times in a second. A message can be sent through it by the usual Morse code, there being no apparent interference between the tuning-fork vibrations and the message. But at the other end of the line, the message can be taken off through a tuning fork in unison with the first. Consequently, if a tuning fork of different pitch is interposed at each of several stations served by one wire, and the messages are sent through forks of corresponding pitch from the head office, the message to one station will not be repeated at the others during transmission.
>
> "Sir William Thomson, at the Glasgow meeting of the British

Association for the Advancement of Science, gave foreign notoriety to another of the Centennial exhibits that has attracted great attention from the judges of the group to which it belongs. It is a curious device that might fairly find place in the magic of Arabian tales. A membrane is stretched over the end of a short speaking trumpet. The membrane carries a small piece of metal which is, so to speak, the armature of a magnet. The magnet forms part of a telegraph circuit, through which a current is passing. To send a message it is only needful to talk loudly into the trumpet.

"The message is received by a similar trumpet with membrane and armature at the other end of the line; and that trumpet being placed to the ear repeats the sound like an echo. Don Pedro was with the scientific people who tested this instrument on one occasion; so accurately did it reproduce sounds that each member of the party was in turn recognized by peculiarities in voice or accent. The final test was the reading of a paragraph from the news columns of the *Tribune*. Of what use is such an invention? Well, there may be occasions of state when it is necessary for officials who are far apart to talk with each other without the interference of an operator. Or some lover may wish to pop the question directly into the ear of a lady and hear for himself her reply, though miles away; it is not for us to guess how courtships will be carried on in the twentieth century. It is said that the human voice has been conveyed by this contrivance over a circuit of sixty miles. Music can be readily transmitted. Think of serenading by telegraph!"

A conversation over two hundred miles of wire on the lines of the Eastern Railroad is noticed in —

Boston *Post*, Boston *Daily Globe*, Boston *Daily Advertiser* and Boston *Herald* of Nov. 27, 1876.

The Boston *Post* of Nov. 27, 1876, says: —

"The experiments in electric telephony, which Professor A. Graham Bell has been conducting for several years past, have resulted in the development of apparatus by means of which the human voice, as ordinarily used in speaking, can be transmitted with certainty and ease to an indefinite distance — assuredly hundreds of miles. . . .

"The latest experiments with the telephones were made yesterday over the wires of the Eastern Railroad, that day being selected because the trials would not then be interrupted by the ordinary business of the line. Professor Bell, President Rockwell, of the Eastern road, and wife, Miss Stearns, Mr. Morrison, and Mr. Hubbard, besides two telegraph operators, were the occupants of the Boston office. The instruments were arranged for about a twenty-mile test, consequently Salem, about sixteen miles away, was the point at which the second telephone was fixed. Mr. Thomas A. Watson, assisted by the Salem operator, was in charge there. All those at the Boston end of the line held free and easy conversation with the Salem office, even a whisper or a loud breath being distinctly heard at one end when given at the other."

Jan. 13, 1877, Professor Bell gave a lecture on his electric speaking telephone, with an exhibition of it, before the Washington Philosophical Society, at Washington, D. C. This was reported in the Washington *Evening Star* of Jan. 20, 1877.

The said report in the *Evening Star* begins as follows: —

"*Bell's Telephone.* At a meeting of the Washington Philosophical Society on the evening of the 13th January, Mr. Bell, the inventor, gave to the members a description of the construction and operation of his most admirable and wonderful invention, *and exhibited it in operation.*"

The Boston *Daily Advertiser* of Jan. 22, 1877, contained the following: —

"The most important of the tests made recently by Professor A. Graham Bell, in the practical development of telephony, is dispensing with the use of the battery entirely, so that now all that is required to communicate between the most distant places is simply a line of wire and the telephones.

"Yesterday morning successful experiments were made between Boston and Salem, on the Eastern R. R. wire. At the Boston end were Professor Bell, Mr. Nutting, the operator, Mr. E. H. Foster, Mr. William Auld, and Mr. J. B. Parker; and at the Salem end, Mr. T. A. Watson, who is associated with Mr. Bell, and the lady operator.

"Recently two Japanese gentlemen conversed in their own language through the telephones, and had no difficulty in understanding all that they said. An experiment has been made in overcoming an artificial resistance greater than the Atlantic cable, and there is no doubt but that it will be possible to talk across the Atlantic."

The Boston *Evening Transcript* of Feb. 1, 1877, contained a long description of an exhibition of a telephone, in which the following is found: —

"At noon, yesterday, a distinguished party of gentlemen were assembled at the office of the Boston Rubber Shoe Company, on Congress Street, in order to witness a series of experiments performed on the telephone between the inventor, Professor A. Graham Bell, here, and his associate, Mr. Thomas A. Watson, at the residence of Mr. Converse, at Malden, about six miles distant.

"Professor Bell had been invited by some of our most prominent citizens to give a practical demonstration of the most recent developments of an invention which, in accordance with its name, has already sounded far and wide the fame of the telephone. The experiments yesterday were as follows: —

"Telephones having been connected with the private telegraphic line of the Boston Rubber Shoe Company, and the operators at either end having taken up their station, conversation was at once commenced. Stationed at the Boston end of the wire, Professor Bell requested Mr. Watson to speak in loud tones, with a view of enabling the entire company at once to distinguish the sounds.

"This was so successful that a smile of mingled pleasure and surprise played on the features of those present. That it, however, might not be supposed that loud speaking was essential to intelligibility, Mr. Bell explained that soft tones could be heard across the wires even more distinctly than loud utterances, even a whisper being audible. In confirmation of this statement, Mr. Watson commenced speaking in turn to each member of the company, and after the efficiency of this method had been proved to the satisfaction of all, he took up a newpaper and informed the assemblage that gold had closed the previous evening at New York at 105^5.

"As there were quite a number of business men present, the effect that this practical demonstration of the value of the telephone produced can scarcely be exaggerated. Other passages from the daily journals were then given, and by this time the desire for conversation having become general, Mr. Watson was plied with questions such as, Is it thawing or freezing at Malden? Who is to be the next president? etc., etc. It was remarkable that Mr. Watson was able to distinguish between the voices at the Boston end, he calling at least one gentleman by name as soon as the latter commenced speaking.

"This went on for some time until a lady at the Malden end sent the company an invitation to lunch per telephone, and an appropriate response was made by the same medium.

"At length the company were requested to remain quiet while a lady at the other end conveyed to them the sweet strains of music. The assemblage thereupon listened with rapt attention while a young lady commenced singing 'The Last Rose of Summer.' The effect was simply charming. Possessing as the fair cantatrice does a voice of exquisite sweetness, the sounds penetrated into the Boston end of the telephone with a distinctness equal to that attainable in the more distant parts of a large concert room, and a unanimous vote of thanks was sent by the handy little instrument which had procured for the assemblage so agreeable an hour.

"Among those present were electricians and gentlemen occupying prominent positions on our Western railroads, and one and all expressed the conviction that the telephone was destined to achieve the greatest possible results. Let us hope that the day is fast approaching when every man will be in a position to turn on the electricity in his house with the same facility with which he now turns on the water or the gas. C. H. H."

Early in 1877 Professor Bell began to give public lectures and exhibitions of his electric speaking telephone.

He gave one in Salem, Mass., Feb. 12, 1877; and a report of it, published in the Boston *Globe* of Feb. 13, was transmitted from Salem to Boston by his speaking telephone.

The said *Globe* of Feb. 13, 1877, contained the following: —

"We have the pleasure of presenting to our readers this morning the first despatch ever sent to a newspaper by the newly invented telephone, Professor A. Graham Bell's system of transmitting sound by telegraph. The despatch was sent from Salem, where Professor Bell lectured last evening, our active representative in that city having secured the exclusive privilege of the instrument for that purpose. The message was received in this city by another representative of the *Globe*, who could readily recognize the voice at the other end.

. . . .

"SENT BY TELEPHONE. — THE FIRST NEWSPAPER DESPATCH SENT BY A HUMAN VOICE OVER THE WIRES. — TO THE DAILY GLOBE FROM SALEM. — PROFESSOR GRAHAM BELL EXPLAINS HIS VALUABLE INVENTION. — AN ENTHUSIASTIC AUDIENCE. — HOW THE CAPACITY OF THE TELEPHONE WAS TESTED.

"*Special Despatch by Telephone to the Boston Globe.*

"SALEM, Feb. 12, 10.55 P. M. — Professor A. Graham Bell, the inventor of that wonderful instrument, the telephone, which has caused so much interest in the scientific world, and which is now becoming so popularly known, lectured on his invention at Lyceum Hall this evening. The lecture was one of a course of the Essex Institute, and about five hundred persons were present.

. . . .

"Mr. Watson was then asked to make a speech to the audience. He expressed himself as having more confidence eighteen miles away than if he were present. His speech was as follows: —

"'*Ladies and Gentlemen,*— It gives me great pleasure to be able to address you this evening, although I am in Boston and you in Salem.' This could be heard thirty-five feet distant, — that is, all over the hall, — and brought down the house with applause. A system of questioning was then carried on, and Mr. Watson was asked if he heard the applause. The answer was, 'I was not listening; try again.' The applause was given, and its receipt at once acknowledged in Boston. Coughing and singing were then heard, and a variety of questions were then asked from the Salem end, and among them, 'What news from the Electoral Commission?' followed by the distinct answer of 'I don't know of any.' But the news came fleeting along that the engineers of the Boston and Maine Railroad had struck. Gen. Cogswell asked if trains were running; the answer was clear and distinct that they were not at 5 30 o'clock. Professor Bell introduced the Rev. E. C. Bolles, who said, 'I shake hands with you cordially in imagination twenty miles away.' The Rev. E. S. Atwood asked, 'Does it rain?' 'It does not in Boston,' was Mr. Watson's answer. Professor Gage, the electrician, then spoke through telephone, endeavoring to have his voice recognized. This could not be done, as Mr. Watson was not familar with the voice. Mr. Shaje Zsawa was recognized, Mr. Watson being perfectly familiar with his tones. One of the assistants in Boston then said that 'Hold the Fort' would be sung in Boston, and the tune was readily recognized. Professor Bell closed his lecture by briefly stating the practical uses to which he was confident the telephone could be applied. Hearty applause was afforded the lecturer as he finished, and people flocked about the stage in large numbers to more closely examine the wonderful instrument that had placed them in audible communication with people nearly twenty miles away.

. . . .

"This special by telephone to the GLOBE has been transmitted in the presence of about twenty, who have thus been witnesses to a feat never before attempted; that is, the sending of a newspaper despatch over the space of eighteen miles by the human voice; and all this wonder being accomplished in a time not much longer than would be consumed in an ordinary conversation between two people in the same room. H. M. B.

"THE SCENE AT THE BOSTON END.

"The instrument which transmitted the wonderful voice-message to the listening ears in this city was placed in a little room in Exeter Place, where were assembled Professor Watson, Benjamin Bridden, the electrician, Professor E. B. Warman, and Mr. A. B. Fletcher, representative of the GLOBE. The experiment was certainly a great success. The conversation with the friends eighteen miles away was carried on in ordinary tones of voice. The GLOBE representative in Boston very easily recognized the voice of the transmitter of the despatch in Salem; and very distinctly heard the applause which was given in the Essex Institute Hall. It was a very noteworthy occasion, certainly; and the complete success attained led to the discussion of many plans for the further practical utilization of the telephone, which sends its first newspaper despatch to the GLOBE readers for their delectation and wonder this morning."

The Boston *Daily Globe* of Feb. 15, 1877, contained the following: —

"THE TELEPHONE. — SOMETHING ABOUT THE CONSTRUCTION AND WORKING OF PROFESSOR BELL'S WONDERFUL INVENTION.

"As the telephone, the new invention of Professor A. Graham Bell, is but little understood, the following reprint of a description and explanation of the instrument may not be amiss: —

"'The telephone in its present form consists of a powerful, compound, permanent magnet, to the poles of which are attached ordinary telegraph coils of insulated wire. In front of the poles, surrounded by these coils of wire, is placed a diaphragm of iron. A mouthpiece to converge the sound upon this diaphragm substantially completes the arrangement. The motion of steel or iron in front of the poles of a magnet creates a current of electricity in coils surrounding the poles of the magnet, and the duration of this current of electricity coincides with the duration of the motion of the steel or iron moved or vibrated in the proximity of the magnet. When the human voice causes the diaphragm to vibrate, electrical undulations are induced in the coils environing the magnets precisely analogous to the undulations of the air produced by that voice. These coils are connected with the line wire, which may be of any length, provided the insulation be good. The undulations which are induced in these coils travel through the line wire, and, passing through the coils of an instrument of precisely similar construction at the distant station, are again resolved into air undulations by the diaphragm of this instrument.'

"It was by this wonderfully simple instrument that the three quarters of a column report of Professor Bell's lecture was transmitted from Salem to the GLOBE by the voice on Monday evening. All who saw the working of the instrument were astounded at the results obtained."

The lecture at Salem was followed by a series of lectures in Boston, Providence, Lowell, Manchester and New York, and these were extensively noticed in newspapers in different parts of the country: *e. g.*, the New York *Sun*, Feb. 20, 1877, had nearly a column about the lecture at Salem, with a description of the apparatus; Boston *Journal of Chemistry*, March 1, 1877, had a long account; also, the New York *Times; Daily Graphic*, of March 6, 1877, with illustations; *Scientific American*, March 31, 1871, with illustrations; *Frank Leslie's*, March 21, 1877, with illustrations; the *Athenæum*, London, England, March 3, 1877.

Feb. 23, 1877, a second lecture and public exhibition was given at Salem. A long report of this was transmitted by telephone, and published in the Boston *Daily Globe* of Feb. 24, 1877. That report contains the following: —

"*Special Despatch by Telephone to the Boston Globe.*"

"SALEM, Friday, Feb. 23, 10.20 P. M. — Lyceum Hall has been crowded this evening with an audience of five hundred, which had assembled to hear Professor A. Graham Bell's interesting lecture on his wonderful invention, the telephone, and the results obtained by the evening's exhibition were certainly most astonishing. This was the second public exhibition of the new invention and its practical uses, and Salem has been fortunate indeed in having both given before her citizens. This second lecture and exhibition was given in response to an invitation to Professor Bell, by a number of scientific gentlemen and prominent citizens, and the audience was one which only a rare and notable occasion can draw together in Salem. Among the more prominent people in the audience were the Hon. George B. Loring, Judge Endicott, of the Supreme Court, Professor D. B. Hagar, of the State Normal School, Dr. J. R. Nichols, of Haverhill, editor of the Boston *Journal of Chemistry*, Judge Osgood, Mayor Oliver, Aldermen Daton and Stone, Professor John Robinson, ex-Mayor Williams, Dr. Henry Wheatland, president of the Essex Institute, the Rev. Messrs. Arey, Dean and Atwood, John W. Perkins, master of the Salem High School, General William Cogswell, J. S. Packard, Esq., and many other prominent citizens. The experiments were similar to those given at the former lecture, and were eminently successful, receiving hearty applause. Professor Thomas A. Watson, Professor Bell's assistant, transmitted several messages from the Boston end of the telephonic wire.

. . . .

"The company at the Boston end of the telephonic wire between Boston and Salem was quite as numerous as Professor Bell's laboratory could well accommodate. It is a little room at the end of Exeter Place, up three flights of stairs, with the various instruments of the telephonic apparatus to be seen on every hand. On one of the tables were the models on which Professor Bell worked out the telephone as it now exists; and they form an interesting study. Books, letters, and papers, all pertaining in more or less degree to the science of electricity, are arranged about the room, which is plainly and tastefully furnished. Occupying the post of duty near the working instrument, was Professor Thomas A. Watson, Mr. B. F. Bridden having charge of the working of the electric apparatus, with two young lads as assistants. The company present included Mr. D. P. Richards, who has been one of Professor Bell's co-workers, the Hon. Charles Levi Woodbury, John C. Hoadley, of Lawrence, Dr. Henry I. Bowditch, Dr. C. J. Blake, Mr. W. A. Hovey, and Mr. C. E. Hurd, of the *Transcript*, three gentlemen from one of Dr. Tourjee's Tabernacle choirs, a cornet player, and an artist who was illustrating the scene for the *Scientific American*, besides reporters from the various city papers.

. . . .

"THE GLOBE despatch then came, followed by another press message, giving merely the news furnished by THE GLOBE about the telephone a week ago. Then 'Yankee Doodle' and 'Auld Lang Syne' were sung by Professor Bell, and distinctly heard in every tone by all in the room; and at 10.30 the conference came to an end."

At Boston three lectures were given in the Music Hall in May, 1877, and at each of them articulate speech was publicly transmitted. The exhibitions at Boston and Providence were reported in the principal newspapers: *e. g.*, Providence *Journal* of April 6, 1877, the Boston papers of April 6, and of May 5, 8, 9, of 1877.

Similar lectures were given during the first half of the year 1877, in Salem, Boston, Lawrence, Lowell, Manchester, Springfield, Providence, New York and elsewhere. At all of them electric speaking telephones with metallic diaphragms were used; at all of them the electric speaking telephones were publicly exhibited, their construction and operation explained, and they were publicly used in the transmission of articulate speech. At these exhibitions an admission fee was charged and paid by the audience.

The *Sun*, *Tribune*, *Herald*, *World* and *Times*, of New York, of May 12, 1877, had long accounts of an exhibition of the speaking telephone by Professor Bell, in the presence of General Eckert, President of the Atlantic and Pacific Telegraph Company, President Gibbs of the Dominion Telegraph Company, President Barnard and Professors Newberry and Rood of Columbia College, and many others, at the St. Denis Hotel. The following is the article from the New York *Tribune:* —

"An exhibition of the speaking telephone was given last night at the St. Denis Hotel, in this city. An invitation to exhibit the instrument here had been tendered to Professor A. Graham Bell by Professor F. A. P. Barnard, Dr. Howard Crosby, Professor Henry Morton, and two or three dozen other gentlemen eminent in the learned professions or connected with telegraphy. Before beginning his proposed course of lectures, Professor Bell invited a few of his scientific friends to be present at an informal exhibition, to show the power of the instruments. About fifty gentlemen were gathered in one of the parlors of the St. Denis Hotel last evening. Among those present were President Barnard, Professor O. N. Rood, and Professor J. S. Newberry, of Columbia College; the Rev. Dr. Armitage; General Eckert, President of the Atlantic and Pacific, and the Hon. T. N. Gibbs, President of the Domestic Telegraph Company; Professor Peet of the Deaf and Dumb Asylum; Eastman Johnson, General Gaylord, S. A. Bunce, R. H. McCurdy, F. O. Evans, and other well-known citizens. There was some delay about the proceedings, which was afterwards explained.

"Professor Barnard introduced Professor Bell to the audience, having become acquainted with the instrument and the inventor at Philadelphia. Professor Barnard stated that of all the instruments of precision and research, etc., which the group of Centennial judges, of which he was chairman, was called upon to examine, there was none that occasioned greater interest or that they regarded as of higher novelty and importance than the speaking telephone of Professor A. Graham Bell. In introducing Professor Bell to the audience, Professor Barnard said that he did so with the conviction that the name of the inventor of the telephone would be handed down to posterity, with a permanent claim on the gratitude and remembrance of mankind. Professor Bell expressed himself as surprised at the size and importance of the gathering. He had at first expected only a small number of his friends, and had arranged to exhibit his telephone merely by placing one of the instruments in one room, and another in another room, in the hotel, connecting them by wires. But at a late hour he had determined upon a more complete exhibition of the character of the instrument, and had therefore sent his assistant, Mr. Gower, to Brooklyn, and hoped before long to hear that Mr. Gower had arrived somewhere in that city, to hear it from Mr. Gower through the telephone. While Professor Bell was speaking, a sound was heard from the instrument; he placed his ear against it, and after listening for a moment, said to the audience: 'It is all right. Mr. Gower has been in search of a cornet player, and thinks he will have one to play a tune for us.' Professor Bell then carried on a brief conversation with Mr. Gower, finally desiring the latter to be in readiness after a short interval, in which Professor Bell proposed to explain some features of the instrument to his audience.

"Professor Bell mentioned many of the facts with which our readers are already familiar, as to the construction and character of the instrument. When a magnet approaches a bar of iron, it generates a current or a change of electrical condition in the iron; when it is drawn back it generates the converse electricity: *i. e.*, in the one case positive, in the other negative. What Professor Bell had done was to substitute a sheet or plate of iron for the bar, to make that vibrate instead of the magnet, and to keep the magnet stationary. The vibration was communicated to the plate in front of the poles of the magnet by the waves of sound striking on the plate. These differences of positive and negative electricity, transmitted through the wire, caused a magnet at the other end of the wire to attract or repel a precisely similar iron plate; and the vibrations of that, communicated to the air, were sounds precisely corresponding to those presented at the first plate. He has tested it on two hundred and fifty-eight miles of wire between New York and Boston. He commenced by understanding it; now he does not understand it.

"The vibration was supposed to be like that of a membrane, such as is that of the drum of the ear. But we all know that such vibration can be readily dampened by fastening upon the membrane something to stiffen it.

"There was no such result with the telephone when a wooden ring was screwed to the plate; or when the plate itself was made of extraordinary thickness, the vibration is molecular. The curious sounds heard in the telephone were described; some of them had been ascertained to proceed from earth currents. The instrument was more sensitive than a galvanometer to certain imperfections in the wire, or imperfect connections.

"The cornet player at last arrived. He was borrowed for a brief period from the orchestra of a neighboring theatre. He played two tunes, the latter one being very distinctly heard. When the note happened to strike the fundamental note of the telephone box it sounded abnormally loud. Otherwise it was fairly rendered. The voice of Professor Bell's instrument sounds very much as though it had come through a very long speaking-tube. Some practice is necessary to catch the words uttered, the vibrations giving a sort of confusing rattle. Nevertheless, the success of the transmission is unquestionable.

"After Professor Bell finished speaking, the different members of the audience listened at the instrument, and some of them conversed with Mr. Gower, who was at the telegraph office, No. 340 Fulton Street, Brooklyn. Much laughter was occasioned by Professor Bell getting the word Fulton wrong, after asking Mr. Gower where he was; Professor Bell understood him to say 'Beacon Street,' perhaps having Boston in his mind. The proprietors of the St. Denis Hotel invited the visitors to a repast after the exhibition."

The first New York lecture was given May 17, 1877, and long reports of it were in the New York *Herald*, *Tribune*, *World* and *Times* of the next day. These reports stated that President Barnard and Professor Rood of Columbia College, President Morton and Professor Mayer of the Stevens Institute, Mr. Cyrus W. Field, Mr. William Orton and General Eckert, and Messrs. Preece and Wheeler (of the English Postal Telegraph) were present, and that Mr. Field spoke through the telephone to the operator at Brunswick.

Dr Henry Morton gave a lecture on the telephone, and an abstract of it is in the New York *Herald* of June 14, 1877.

The *Journal of the Telegraph*, March 1, April 1, April 16 and May 16, 1877, describe and refer to Mr Bell's electric speaking telephone, and to Mr. Bell as the inventor thereof.

In the early part of 1877 preparations were made to manufacture and supply electric speaking telephones for commercial purposes.

The Boston *Post* of April 5, 1877, states that a telephone line had been opened between the factory of Mr. Chasles Williams, Jr., in Boston, and his house in Malden, and this is true.

In May, 1877, a contract was made to supply them to the Cambridge Water Board.

In the same month, a set was furnished to Stone & Downer, bankers and brokers, of Boston, for regular use in their business, and agents were employed for various parts of the country; and their public and general commercial use, and the readiness of Mr. Bell's licensees to furnish them, were advertised and noticed in the papers: *e. g.*, New York *Graphic*, May -3, 1877; Worcester *Press*, June 23, 1877; New York *Tribune*, Aug. 17, 1877; Cincinnati *Gazette*, Aug. 15, 1877; Cincinnati *Enquirer*, Aug 19, 1877.

A circular signed by me, and dated May, 1877, offering to fill orders for telephones and lines, was in that month widely distributed.

The *Scientific American* of Oct. 6, 1877, has a long article entitled "The New Bell Telephone." It is illustrated by large wood-cuts of the hand telephone now in commen use, and of the manner of using the same. Said article describes the structure of the apparatus and its mode of operation. It concludes with the following paragraph:—

"The telephone has advanced considerably beyond the status of a 'beautiful scientific toy,' which many hastily pronounced it, and is now in constant use in numerous private lines in New York, Boston and Providence. Professor Bell recently exhibited it before the British Association at Plymouth, England, where it attracted great attention. It is at present manufactured by the Telephone Company, of New York, Mr. Charles A. Cheever, manager, 32 Tribune Building, in this city."

As matters which I know from my knowledge of the business, without being personally present on the occasions referred to, I state:—

Bell magneto-telephones, with metallic diaphragms and permanent magnets, were supplied by Mr. Bell's licensees to the following offices of the government at Washington, and were thereafter used by them publicly for the transmission of articulate speech in the ordinary course of business:—

October, 1877. Office of chief signal officer to Fort Whipple, Va.

November, 1877. Same office to signal station, Baltimore.

January, 1878. Same office to Soldiers' Home.

October, 1877. United States Senate to Public Printing Office.

November, 1877. Treasury Department to house of Secretary of the Treasury.

December, 1877. Post-Office Department, chief clerk to topographer.

December, 1877. Depot quartermaster's office to corral.

December, 1877. Chief clerk State Department to White House.

January, 1878. Ordnance Bureau to Arsenal.

Mr. Edison's form of telephone, commonly known as the carbon telephone, which operates by a variation of resistance produced by the motion of the diaphragm, was used in transmitting articulate speech between Philadelphia and New York before April 3, 1878, and an account of such use is found in the Philadelphia *Record* and Philadelphia *Times*, of April 3, 1878.

The said Edison telephone was publicly exhibited and used in Washington before the Academy and elsewhere, on April 15, 1878, and a full description and account of this is found in the Philadelphia *Press* of April 16, and in the Washington *Post* and *Star*, of April 19, 1878.

Before July 1, 1878, this form of telephone was publicly used by the Gold and Stock Telegraph Company, and offered by them for public and general commercial use.

On Aug. 1, 1877, the owners of the said Bell patents had manufactured for public commercial use nine hundred and twenty-eight electric speaking telephones, exclusive of those made for and used by Mr. Bell in the exhibitions I have described; of these, seven hundred and eighty were on said day in actual use, in addition to those on hand and a certain number which were or had been in occasional or temporary use.

July 1, 1878, the number so made for public commercial use by said owners was 11,258, and the number in actual public commercial use was 10,775.

July 20, 1880, considerably more than 100,000 were in actual commercial use, and many others had been in use and replaced by improved forms.

All those put out for commercial use have been provided with metallic diaphragms.

THOASM A. WATSON.

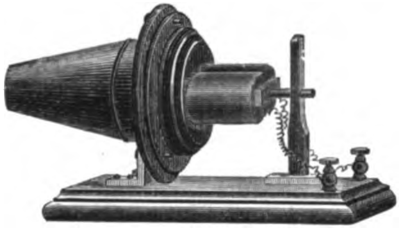
STATE OF MASSACHUSETTS, }
COUNTY OF SUFFOLK. } ss.

Sworn and subscribed to before me this twenty-fifth day of May, 1881.

[SEAL]

GEO. WILLIS PIERCE,
Notary Public.

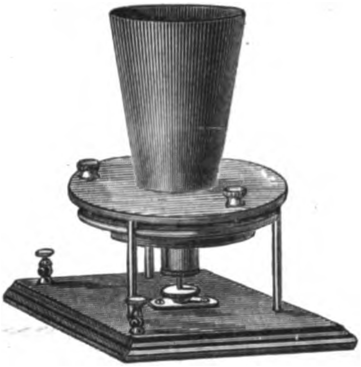
COMPLAINANTS' EXHIBIT 4, BELL'S DOUBLE POLE CENTENNIAL MEMBRANE TELEPHONE.



DIMENSIONS.

Length of cone	$4\frac{3}{4}$	inches.
Diameter of membrane	3	"
Length of spools	$1\frac{3}{4}$	"
Diameter of spools	$1\frac{}{8}$	"

COMPLAINANTS' EXHIBIT 5, BELL'S CENTENNIAL LIQUID TRANSMITTER.



DIMENSIONS.

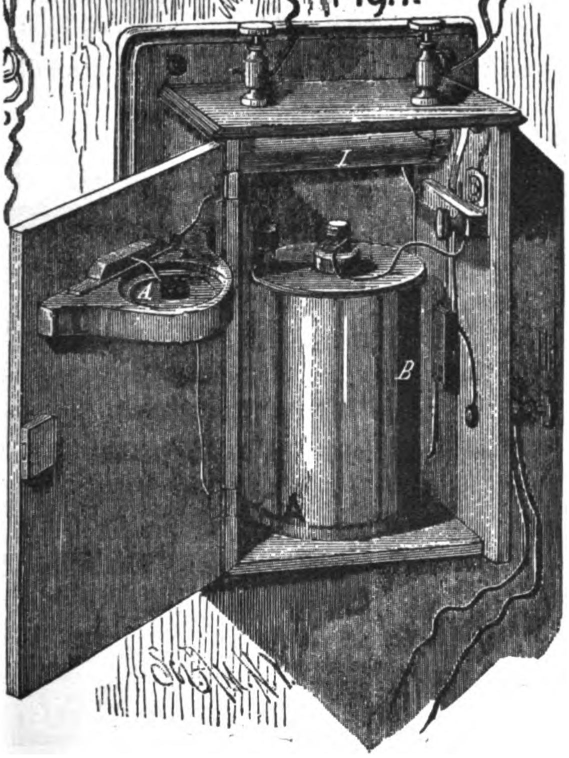
Diameter of membrane	3	inches.
Diameter of cup	$\frac{3}{4}$	"
Depth of cup	$\frac{1}{2}$	"
Length of cone	6	"

AFFIDAVIT OF EDWARD DAVIS.

[Filed Oct. 10, 1881.]

My name is Edward Davis; age, forty-two years; residence, Cambridge, Mass.; occupation, telegraph machinist. I am familiar with electric speaking telephones, and for three years have been exclusively engaged in the construction and repair of telephones and telephonic apparatus. I am acquainted with the receiving telephone recently patented by Prof. Amos E. Dolbear, which, with a microphone transmitter, was described at length in the "Scientific American" of June 18, 1881. A set of these instruments are, and for some time have been, in operation on a line connecting the office of F. M. Holmes, 107 Washington Street, Boston, with the rooms of Prof. Dolbear, 70 Washington Street, Boston. In the early part of July last these instruments were on exhibition, and many persons saw them and talked through them. I examined them at about that date. The transmitter used was similar to that shown in the articles in the "Scientific American" of June 18, 1881. The following figure, marked "Fig. 1," illustrates this instrument.

Fig. 1.



A is the diaphragm, which is about the size of that used in the Blake transmitter. It is clamped around the edge, and covers an air chamber, as shown in Fig. 2.

Fig. 2 -

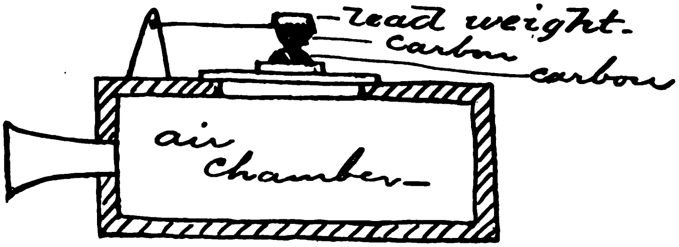
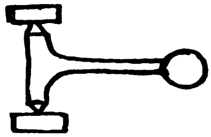


Fig. 3 -



The contacts are both of carbon, and the upper one is weighted with lead and supported by a lever arm pivoted as shown in Figs. 2 and 3. One cell of battery is used similar to the Lechanché. The coil I (Fig. 1) has a very low resistance primary, and a secondary of very high resistance. The receiver is shown in section in Fig. 4, and in perspective in Fig. 5. It consists of two diaphragms of

Fig. 4.

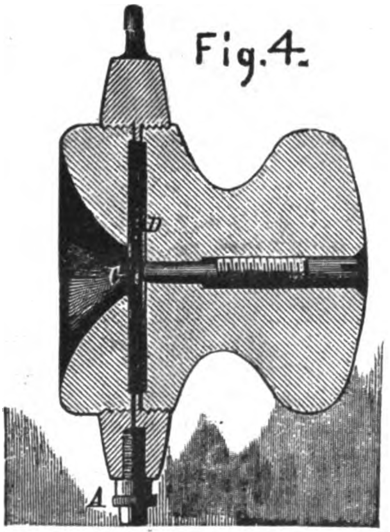
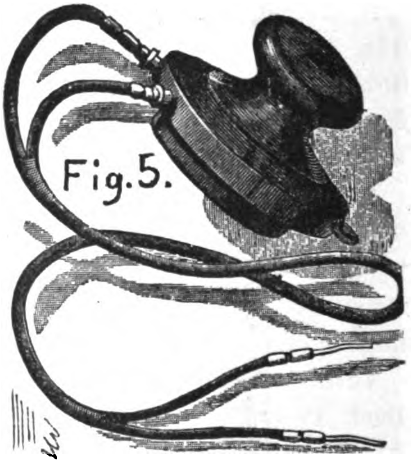


Fig. 5.



about the size and thickness of those used in an ordinary Bell telephone, mounted in a hard rubber frame R R′, with an intermediate space of about one twentieth of an inch between them. The adjusting screw S enables the distance between the plates to be regulated. The two diaphragms are connected to two binding screws, one of which connects to line and the other to earth, as shown in the accompanying diagram, marked "Fig. 6."

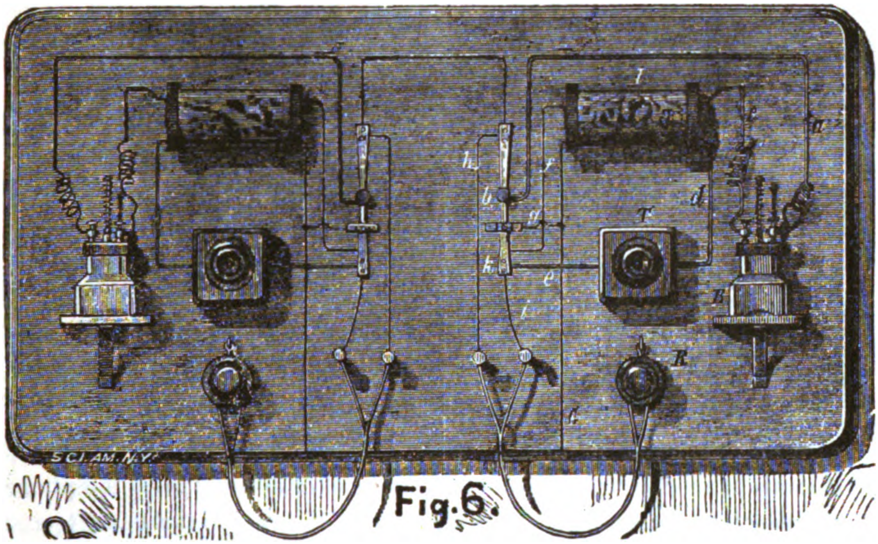


Fig. 6.

In talking, the key *k* is pressed down, and the primary circuit is from battery B by wire *p′* to coil I, then to transmitter T, then through *k* back by wire *p″p″* to battery. The secondary circuit is from earth by wire *s* up through the coil and then out through the key to line.

In listening, the key *k* is left up, and the current comes in from line through *h* to the receiver R, thence to *k* and by the little wire *g* to earth. I talked over the line, using the instruments referred to for speaking and listening, and found them adapted for the transmission of articulate speech.

These instruments were shown and explained to me by Mr. H. C. Buck, Prof. Dolbear's assistant, who also informed me that several sets of the Dolbear telephones were then in actual use, and that a company was about being formed for putting them extensively into public use.

EDWARD DAVIS.

STATE OF MASSACHUSETTS,
COUNTY OF SUFFOLK, SS.

Subscribed and sworn to before me this twelfth day of September, A. D. 1881.

GEO. WILLIS PIERCE,
[SEAL] *Notary Public.*

AFFIDAVIT OF ALBERT H. CHAPMAN.

[FILED OCT. 10, 1881.]

My name is Albert H. Chapman; my age is forty years; I live in Boston; I am an electrician. Last summer I was an agent for the Gold and Stock Telegraph Company in Boston. I now have charge of private telephone lines for the American Bell Telephone Company in Boston. I know Prof. Amos E. Dolbear of Somerville, Mr. F. M. Holmes and Mr. H. C. Buck, Mr. Dolbear's assistant, of Boston, and Mr. Henry B. Metcalf of Pawtucket, R. I. Early in July of this year I went to the workshop of Prof. Dolbear, 70 Washington Street, Boston. I there met Mr. Dolbear and Mr. Metcalf, and talked with them. Mr. Buck was present, but I did not directly converse with him. Mr. Dolbear showed me a telephone transmitter fastened to the wall, and a receiver hung near it, and told me that they were connected by a wire with another set of instruments at the store of Mr. F. M. Holmes, 107 Washington Street, Boston. He told me that these sets of instruments were of his own construction and constructed by his direction, and that by them a conversation could be carried on. At his invitation I then did, by these instruments, carry on a conversation with some person who they said was at Mr. Holmes's store. This transmitter and receiver were opened and shown to me, and I saw their construction. They are like those described in the affidavit of Mr. Davis in this case. In addition to these instruments, there was another set which connected with a wire running to another part of the building, and which I understood was for experimental purposes. A conversation then took place concerning the manufacture and sale of such telephones. Mr. Metcalf said that he was interested in them, and that he and his associates proposed to construct them and put them out to the public for general use, and that for that purpose they intended to get up a corporation. He said that Mr. Holmes was interested with them, and was the principal moneyed man. The probable cost of manufacturing them was discussed, and Mr. Metcalf said that he had figured what it would cost. We were all three sitting together, and Mr. Dolbear took part in the conversation and spoke of these plans substantially as Mr. Metcalf did. Both of them said that they should not be deterred by the patents of Mr. Bell from making and putting out telephones; that they should take the ground that their instruments were different from Mr. Bell's, though they expected that the Bell company would interfere, and that there would be litigation. The decision of Judge Lowell in the Spencer case was spoken of, and they expressed the opinion that it was wrong.

Sept. 15, 1881, I was again at Mr. Dolbear's same rooms. I there and then met Mr. Dolbear. We conversed about his telephones, and in the course of his conversation he said that he and his associates intended to make and put out his telephones, and that they should organize a company for that purpose as soon as Mr. Holmes returned; that Mr. Holmes was then out of town, but was expected shortly. The instruments were up, substantially the same as at my previous visit. They appeared to be the same as those described in the affidavit of Mr. Edward Davis in this case.

There is a telephone line from the furniture store of F. M. Holmes & Co., 107 Washington Street, Boston, to their furniture factory in East Cambridge. It is furnished with the telephones of the American Bell Telephone Company, and is used for the regular furniture business of the said Holmes & Co.; I understand that Holmes & Co. own the wire.

After I saw Prof. Dolbear, on Sept. 15, I went into Mr. Holmes's store and there saw a set of telephones fastened to the wall near the Bell telephones which connect with said line to East Cambridge. I recognized them as the Dolbear instruments, transmitter and receiver. The person in charge said that as soon as Mr. Holmes got home they would be connected to that line and used on it.

I again saw said Dolbear telephones at the same place in Mr. Holmes's store, Sept. 21, 1881. Another person who appeared to be in charge of the room said that Mr. Holmes had been so busy that he had not time to connect them, but was going to connect them and use them right away.

On Oct. 6, 1881, I went to Mr. F. M. Holmes's warehouse, 107 Washington Street, Boston. The Dolbear instrument I formerly saw there arranged with the East Cambridge line had been removed, and the man in charge of the office said that they had been used, but did not work satisfactorily, and that Prof. Dolbear had taken them to his laboratory, and he said he supposed they intended to bring them back. On the same day I saw Mr. F. M. Holmes at the same place. He told me that he and his associates intended to have started in the business of making and putting out telephones before this time, and expected to have got up a company for the purpose in the early part of July last; but that the assassination of the President had made them hesitate on financial grounds about putting out sufficient money to put the enterprise on such a basis as they intended. He said that now they intended to proceed and manufacture and put out telephones for general use and introduce them, and expected to do so very soon. He said that he considered that the Dolbear instruments were entirely different from the Bell instruments, and that he should not be deterred from going forward by any claim that his instruments infringed the Bell patents.

In speaking of what was intended to be done about the Dolbear instruments, he invariably used the pronoun "we," and I understood from him that he and others had joined in the enterprise to make them and introduce them.

ALBERT H. CHAPMAN.

UNITED STATES OF AMERICA, }
DISTRICT OF MASSACHUSETTS, } SS.

Subscribed and sworn to this seventh day of October, 1881, before me.

WM. S. DEXTER, *Commissioner U. S. Circuit Court.*

AFFIDAVIT OF THEODORE N. VAIL.

[Filed Oct. 10, 1881]

I, Theodore N. Vail, a witness of lawful age, on oath depose and say: I am the general manager of the American Bell Telephone Company. I have been connected with the companies owning the Bell patent since June, 1878, as general manager.

I have read Mr. Watson's affidavit in this case. All the statements therein contained relating to matters during my connection with these companies are true. I was personally concerned in the settlements made by the Western Union Telegraph Company and others, in consequence of the Dowd suit.

Since the publication of the two patents of Mr. Bell, Nos. 174,465 and 186,787, it has been easy and inexpensive for any one (who had the right so to do) to make electric speaking telephones sufficiently good for practically useful work. The public appreciation of their utility, and the demand for their use, have been such that if no further improvements had been made in them, or in the arts directly connected with them, I am sure that large numbers would have been called for and used, at remunerative prices. But the present demand for them, and the extent of their use, are very largely due to the efforts which have been made to introduce them, and to perfect the appliances for, and organization of, the telephonic systems, of which the telephone itself is the essential and controlling part. Every pair of instruments now in use has required the construction of a line of wire, of call bells, alarms, switches and batteries. The telephonic exchange system requires the establishment of a system of wires leading from the subscribers' premises to a central office, the preparation of a central office, suitable provisions there in the way of elaborate and expensive switch boards, signals and other devices, by which any one of several thousand subscribers can, with the least possible delay, be put into direct and private communication with any other. Substantially all the apparatus in use for these purposes has been newly invented, or has been modified from old forms to meet these new demands. Many such improvements — to the amount of several hundred — have been patented; but a very large, and perhaps the most important part of them, consist in modifications of form and of workmanship which, though not patentable, have been the result of careful and expensive experiments, in the course of which those engaged in them have been obliged to withdraw from use and condemn many thousands of instruments, not because they were not operative, but because others were better.

In addition to this, the manner of organizing and establishing the business, and particularly the establishment and operation of exchanges and lines in large cities, has been the subject of much study and expense in acquiring the needed experience. In the course of this, many systems of lines and apparatus have been discarded, and rebuilt or reconstructed. The knowledge and experience thus gained has been the most expensive, and perhaps, on the whole, has constituted the most important progress, of which the public and the persons concerned have had the benefit.

Substantially all this improvement has been made by the owners of Mr. Bell's patents, and those who operate under them, or in direct connection with his licensees. As one item of expense, I will mention that one such corporation has expended more than $100,000 in instruments alone which have been condemned, because superseded by improvements. I am quite sure, from my knowledge, that the experience thus gained, and of which any person who can freely make and use telephones can have the benefit, has actually cost the licensees under the two Bell patents more than half a million dollars.

As nearly as I can ascertain (and my duties enable me to have as accurate information on this subject as any one), upwards of 100,000 signal instruments and switches have been manufactured and put into use on telephone lines; from 50,000 to 75,000 miles of telephone wire put up; telephone exchanges established in more than four hundred places, in every State in the Union, including nearly all the cities in the United States of over 5,000 inhabitants; and more than 160,000 telephones are in use on such lines and exchanges, under license from the said Bell patents.

Many million dollars of capital is represented by this business and embarked in it. The Bell company and its licensees have put in and actually expended in experiment and construction, in the manner, and for the purposes I have stated, in actual cash, more than $3,000,000 in excess of the amount withdrawn in dividends since the business was established. I believe that if the protection of the patents under which they have embarked shall be continued, they will receive handsome returns for their outlay, and it has been made in this belief; but if the Bell patents are invalid, much of this money would be lost. So long as the patents under which they have invested their money continue to be respected as they have been, the owners and licensees under them will be able to be remunerated for the expensive knowledge and experience which has been gained, because it all relates to or is auxiliary to the use of the patented telephones; but the character of what has been done is such that if protection cannot be had under those patents, and telephones can be used without license under them, the new-comers will largely reap the benefits of what has been gained at the expense of those who have spent their money, relying upon these patents for its return.

If by inability to obtain preliminary injunctions the manufacture and use of telephones should be practically thrown open to the public during the time which I am informed is needed to bring a suit on the patents to final hearing, I am of opinion that the evils to the present owners and licensees and the benefits to infringers, which I have above referred to, would be suffered and realized to a very great degree. This would be partly because of the derangement of the business, and partly because the manufacture of tolerably efficient telephones is so easy that the country would be full of irresponsible infringers.

From my knowledge of the business, I am satisfied that such general and unrestrained infringement for two or three years, at the present time, would take away nearly all the incentive to improvement and nearly all the means for improvement on the part of those who carry on the business, and thus the public would be less well served than they would be if the patents are respected.

The complainant has established a telephone exchange covering Boston and its vicinity, and has constructed a large number of private lines of leased telephones in this neighborhood. It has also, at large expense, provided itself with facilities for extending the said business as fast as demanded by the wants of the public; and this business, which has been established for several years, has been seriously interfered with, and the complainant would suffer injury, which would be large and difficult to estimate, if infringing telephones should be made and used. In addition to that, the distribution of telephones among the community by a manufacturer would require and necessarily lead to a large number of suits and great expense and annoyance, both to the complainant and to those who might be guilty of such interfering use. From the nature of this instrument it would not be used by the manufacturer himself at his own factory, but would be provided for the purpose of being furnished to the general public, and so used by them.

I have heard of the telephonic apparatus constructed by Amos E. Dolbear, of Somerville, in Boston, and which is said to contain some improvements or devices which he claims to have invented. Some improvements of that kind are described in the patent No. 239,742, issued April 5, 1881, to said Dolbear, for "Apparatus for transmitting Sound by Electricity."

I have been informed and learn that recently said Dolbear and the defendant, Francis M. Holmes, and others, have associated themselves together for the purpose of manufacturing telephones, inducing others to manufacture them, and of causing them to be introduced into general use in the community, if they can succeed in doing so. June 18, 1881, a description of this apparatus, purporting to have been written by Mr. Dolbear himself, with illustrations, was published in the "Scientific American," a newspaper of large circulation, printed in New York, a copy of which is hereto annexed and made a part hereof.

I have also been informed that a line has been constructed from the establishment of Mr. Dolbear, No. 70 Washington Street, to the furniture warehouse of the defendant, F. M. Holmes; that the public have been invited to freely come and use said line, and that many persons have talked over it by means of speaking telephones constructed by said Dolbear, or under his direction, and connected with it; and that the purpose of said defendants in constructing and arranging said line and instruments, and inviting others to use them, is to facilitate their said scheme of introducing them into general and public use. Said line, I am informed, has also been used by said Dolbear and said Holmes as a means of communication upon their own private business.

I have been informed that said Dolbear and said Holmes have solicited other people, and endeavored to induce other people to join them in their said scheme. I have also been informed that they are arranging to form a corporation, with large capital, for the purpose of manufacturing and selling, or otherwise furnishing to the community, such infringing telephones.

Part of my information on this subject is derived from the affidavit of Edward Davis; and the telephones described in said affidavit of Davis, when arranged in connection with a line and used for the transmission of speech, infringe the patents of Alexander Graham Bell, named in the bill in this case.

THEO. N. VAIL.

State of Massachusetts,
County of Suffolk, ss.

Subscribed and sworn to before me this twelfth day of September, A. D. 1881.

[seal]

Geo. Willis Pierce,
Notary Public.

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SCIENTIFIC AMERICAN DOLBEAR ARTICLE.

[AFFIDAVIT OF THEO. N. VAIL, PAGE 118, *ante*.]

A NEW SYSTEM OF TELEPHONY.

BY A. E. DOLBEAR.

That rubbing a piece of amber will endow it with the property of attracting other bodies has been known from remote times, and it is probable that this phenomenon was the only electrical one known until comparatively recent times. Sulphur, wax, glass, and a few other substances were found to possess the same quality, and latterly it has been discovered that every substance whatever, when subjected to friction from a different kind of substance than itself, is capable of attracting light bodies in the same way as amber and as glass. The difference is one of degree only.

Another phenomenon due to the electrical excitement of bodies by friction is, they attract each other stronger than they attract other bodies, while each of the excited substances will repel a similar body excited in the same way.

But there are other ways of generating electricity that are familiar enough nowadays; for example, the galvanic battery; but this does not exhibit the attractive property of the piece of rubbed glass in a way that is appreciable by ordinary means. A well-excited piece of glass will make a pith ball to move toward it from a distance of a foot or more. But let the pith ball be brought very near to any part of a battery or a wire attached to a battery, and no appreciable motion will take place. If, however, the wires connecting the terminals of the battery be wound into a helix that incloses a piece of iron, the latter will be made a magnet by the current of electricity in the wire, and this magnet will attract other bodies.

A very strong magnet will attract any body whatever, even a pith ball or a piece of hard rubber, but the strongest electro-magnet hitherto made will not attract such a substance to itself from a distance of half an inch. The attractive property manifested by the iron is called *magnetism*, and the corresponding property of the glass that has been subject to friction is called *electrical attraction.*

While it is true that a current of electricity in the wire conductor of a battery is capable of developing an attractive property in the iron, it is also true that the terminal wires of the battery, when they are not connected, manifest an *electrical* attraction, for if they be properly connected to a sensitive electrometer the latter will show them to be electrified, one positively, the other negatively; and, in order to understand better what is subsequently stated, it will be best to dwell a little while upon this phenomenon.

It has been stated above that all substances may be rendered electrical by friction, but for conductors of electricity like the metals friction is not essential; it is only necessary to *touch* one metal to another or to a fluid, like water, when one will be found positive and the other negative. Thus, if a piece of copper is touched to a piece of zinc the copper will be found to be positively electrified, and the zinc negatively; if the copper is touched to water the latter will be positive, and the copper negative; while if the zinc be touched to the water the latter will still be positive, but the zinc will be more negative than the copper was. Now these differences of electrical condition are called differences of potential, and difference of potential is electro-motive force, or the condition which results either in electrical attraction or in a current of electricity in a suitable conductor. A great number of facts lead one to the belief that whenever two different substances are placed in contact there an electromotive force is developed, electricity is generated; and the probable explanation of this is that the atomic and molecular motions of two differently constituted bodies cannot be exactly alike; that is, they cannot be taking place at the same rate in both bodies. The molecules of a dense body cannot be moving as fast as those of a less dense body, and when those differently moving molecules are placed in contact with each other there must be some rearrangement of their motions at the points of contact, and the readjustment is quickly distributed by reaction throughout the whole body if it be what is called a good conductor, and more slowly in a poor conductor, but after such distribution there is no further action unless some means is provided for maintaining fresh surfaces of contact. In the galvanic battery this is effected by the gradual solution of the zinc, by which the surface molecules are removed, thus presenting a fresh surface for renewal of the original conditions. As the electricity thus generated tends to go from the element with the higher potential to the lower one, there will be what is called a *current* through any conductor that connects them so long as the solution of the zinc goes on, but break the wire that connects the two metals and the current will stop, and the ends of the wires will be found to be electrified, one positively, the other negatively.

But electricity may be generated in other ways still, and the method discovered by Henry more than forty years ago is second to none in scientific interest as well as practical use. It is this: that whenever a current of electricity in a conductor is started or stopped, or in any way varied, another current will be generated in an adjacent conductor, but it will have a direction opposite to that of the originating current. This is the foundation of what is now called *inductive coils* or inductoriums. These consist of two coils of wire, one with only a few turns of larger insulated wire wound over a bundle of iron wires, the other coil being wound outside of the first or primary coil, and consisting of a great many turns of very fine wire. The primary coil may be connected to a battery, as in Fig. 5, first page, while the terminals of the secondary coil are generally made fast to some hard rubber mounting, as in Fig. 7. When a current of electricity is permitted to traverse the primary coil the induced electro-motive force in the secondary coil raises one terminal to a higher potential than the other; that is to say, one terminal is positive, the other negative; and, if a wire connects these terminals, a current will flow through it from the positive to the negative terminal. If a galvanometer be connected to them the needle will be deflected by the current. Indeed, it is not necessary to have the wire terminals quite touch each other, for if the electro-motive force be great enough a spark will pass from one to the other, the spark being a part of a transient current, and consisting of some of the material of the terminal that has been torn off, and is transferred to the other terminal because it is electrified positively, and is, therefore, attracted by the other terminal, which is negatively electrified.

That the terminals are electrified at such times may be proved by bringing a pith ball suspended by a thread near to one of them, or attaching one of the brass disks of an Epinus condenser by a wire to the terminal, as E in Fig. 5. Each make and break of the battery current will make the pith ball move toward the disk. This principle of the attractive power of an electrified body for other bodies is the basis of the new speaking telephone about to be described.

THE RECEIVER.

This consists, in its simplest form, of two metallic disks about two inches in diameter, so mounted as not to be in metallic contact, and this is effected by turning a flange in a hard rubber case so they may be kept apart by it (see Fig. 4). A cap is screwed down upon each plate, one of them having a small hole in the middle of it to listen at; the other is a larger one, having a knob turned upon it for conveniently holding it in the hand. Through the middle of the knob a screw is sunk which touches the back plate and serves to adjust it to the best position relative to the front or vibrating plate. The back plate is thus fastened at both edge and middle, which prevents it from vibrating, while the front plate is only fast at its edge, leaving the middle free to vibrate. Each of these plates, A B, Fig. 3, is in metallic connection with the induction coil so as to be its terminals. When thus connected, and one makes and breaks connection in the primary circuit, a click may be heard by one holding the receiver near to the ear. If a Helmholtz interrupter be employed to make and break the primary circuit the pitch of the fork can easily be heard, and with a *Reiss transmitter* or other suitable one in the same place any kind of a sound will be reproduced.

The explanation of this is easily understood from the foregoing description of the conditions present. The electro-motive force generated by induction in the coil changes the two terminals in the receiver, one positively, the other negatively; they therefore attract each other.

One of them is free to move, while the other is rigid. The middle of the freer plate consequently moves slightly toward the other whenever they are electrified, and *in so doing spends the energy of* *the electricity*, while its elasticity brings it back to its place. It is not essential, however, that both of these terminal plates should be connected to the induction coil, for if only one is connected the recurring charges will cause the free plate to vibrate, for a charged body will attract any other body, so if the connection be to the back plate it will attract the front one and make it move, and if the connection be to the front plate it will attract the back plate and approach it. The effect will be increased by putting the finger upon the terminal that is free; not because it *makes a ground*, as it is termed in electrical science, or completes an electrical circuit, for, if the individual listening be as perfectly insulated as glass or hard rubber can make him, the sound is as loud as if he stood on the ground; but the individual becomes electrified by induction, it is the same as enlarging the terminal would be. Consequently receivers are made having only one wire terminal (see Fig. 9), the other plate being connected by a conductor to a metallic ring upon the knob, and this receiver is as efficient as the other.

Electricians will recognize in this structure what is technically known as the *air condenser*, and the mutual attraction of the two plates has been employed as a means of measuring electric potential. In this case one of the plates is suspended from one arm of a balance, while the other is fixed underneath it at a short distance. The attraction of the plates when they are electrified requires an extra weight to keep them apart, and the weight needed is the measure of the attractive force. But the plates will attract each other when glass or mica or any other non-conducting substance is placed between them in the place of the air; and one might expect that if such an air condenser would give sonorous results other forms of condensers would do so likewise, and this is so. Indeed, whoever has charged a Leyden jar has probably noticed the sounds coming from it when it is nearly saturated. In 1863 Sir Wm. Thomson had his attention directed to the sounds produced by discharge in an air condenser.*

When the two plates of Epinus' condenser are in metallic contact no sounds whatever can be produced by it, but if they are separated by a thin film of air, they will reproduce speech (see Fig. 6, at E). In the first case the electricity passes from one plate to the other without doing work or changing its form; while in the latter its form is changed and work is done, and between the best conductors, such as silver and copper and the perfect non-conductor air, there are all degrees of conductibility, and whenever electricity spends its energy upon an imperfect conductor it results in heating it; that is, in molecular and atomic vibrations. Consequently an undulatory current from an ordinary transmitter, when sent through an imperfect conductor, will set up sound vibrations in it which may be appreciated by the ear. Let, then, any poor conductor, like a disk of carbon, a sheet of paper or of gelatine, or such chemical substances as ammonium chloride, be placed between the terminal plates, and an undulatory current sent through them will result in sound, and speech may be reproduced.

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* See papers on Electro Statics and Magnetism, page 236.

Now, the phenomena observed in Geissler's tubes and Crookes' tubes show that the residual gaseous molecules are violently impelled from the electrified terminals, not simply because they are electrified, but because they are heated, for the same phenomena are witnessed when the terminals are heated in other ways; so it is probable that between the plates of the air condenser there is an actual impulsion of the air particles from one to the other, and that the phenomenon of attraction is not isolated from molecular impact. Receivers have been made in which a vacuum could be produced between the plates, but no great difference could be observed in their performance; and, when one reflects upon the immense number of molecules left in the best vacuum yet produced, it is not a matter for much surprise.

When a non-conductor, such as air, or vulcanite, or mica, separates the two plates, there is a complete transformation of the electricity at the limiting surfaces, and with small condensers the efficiency depends upon the electro-motive force employed. For low electro-motive forces, such as common batteries of a few cells can give, the effect is almost inappreciable, and for this reason such a receiver as this is quite free from the disturbance known as induction, and which is so troublesome in the magneto-telephone, such induced currents being generally of low electro-motive force.

Among the earliest of my experiments, made while developing this method, was to attach one terminal wire from an induction coil to the outer coating of a Leyden jar, taking the other wire from the coil in one hand, and applying one ear to the knob of the jar. Every word spoken at the transmitter was distinctly heard, but the prickly sensation due to the electricity was too disagreeable. Another receiver, not less curious than the Leyden jar, was found in the pair of insulating handles made for the medical application of electricity (Fig. 8). When these were connected to the coil wires, and one held in each hand by the wooden part, while the metallic ends were placed at the ears, any kind of a sound at the transmitter was heard without any difficulty, but of course the same sensation was felt as with the jar. Many forms of condensers have been employed with capacities too small to measure up to two micro-farads, and these in all sorts of relations, charging the plates from batteries, from Holtz machines, charging the line as in cable works, etc., all of which give results that differ only in degree.

THE TRANSMITTER.

As with other systems in common use, there is a transmitter as well as a receiver. One form of the transmitter is shown in Fig. 10, it being attached to the door of a box containing battery and coil. This transmitter is substantially the same as the one invented by Reiss in 1861. His consisted of a cubical box (see Fig. 6) about five inches on a side, having an opening on one side to talk into, and another one on top, across which the diaphragm was fastened. A pin of platinum was glued to the middle of the membrane and connected by a wire to a binding screw. A V-shaped wire with platinum point touched upon the platinum of the membrane, and with its binding screw served to complete a galvanic circuit. This one (see Fig. 10) differs from this of Reiss only in making the chamber smaller, making the connecting wire on top I-shaped, and substituting carbon or other suitable substance for the platinum; but the platinum does very well. It is a matter of some surprise that the old transmitter is still spoken of as a *make and break* circuit, and that it can only transmit pitch, whereas, whether it breaks or not when a sound is made in it depends solely upon the intensity of that sound, just as with the Blake transmitter. If one talks gently to the original Reiss transmitter it not only does not break, but it transmits speech with all its qualities.

Accompanying the transmitter an induction coil is shown at I, Fig. 6, and as the working of the receiver depends upon electro-motive force and not upon current, it is necessary, if a coil be used to raise the electro-motive force, to have one with many more turns than is needed with the magneto receiver, and the best results have been obtained with a coil having a resistance of four or five thousand ohms, but it is probable that this will be reduced.

On account of the high electro-motive force a better insulation is needed than ordinary telegraph lines give when the induction coil is at the further end of the line, but if it is at the receiving end, and a low electro-motive force is employed in the primary, then ordinary insulation will answer. Again, the electro-motive force being high, inserted resistances do not so markedly decrease the efficiency of the instrument, as in the case with the magneto telephone. For instance, the articulation is perfect and loud enough with a resistance of fifty thousand ohms, a resistance equal to five thousand miles of common telegraph wire, and it may be heard through the resistance of a million ohms, practically an infinite resistance.

If one of the terminals of a receiver be charged in any way the reaction between the two plates will be stronger than it will be without. Let, then, one terminal be attached to a knob of a Holtz machine that is kept charged by rotation. The sounds will be heard much louder, and any other source of electricity with high potential will answer the same purpose. Hence a battery of a large number of cells may be substituted for the Holtz machine, and one of the terminals of the battery may go to the ground, though this is not essential. This arrangement will keep the terminal plate charged to the potential due to the chemical relations and number of cells in the battery. If the battery be placed in the line wire it will keep both ends of the line charged. A Volta's pile may be substituted for the battery in either place, and so may a charged condenser of any capacity, the electrically charged terminals in this system acting in a way analogous to the permanent magnets in the magnetic system.

There are various other ways of employing condensers, and as one would infer from the preceding descriptions of the phenomena, these condensers will talk, that is, they will reproduce in sound the varying electrical conditions to which they may be subjected, as will also either a battery or a Volta's pile.

I have often heard them talk, and have made many experiments with such receivers.

Several other diagrams are also added, showing some of the various ways in which the system may be employed.

In perfecting this new telephone Professor Dolbear has given long and constant study to the scientific problems involved, while the mechanical construction has been prosecuted by H. C. Buck, aided by skilled machinists and competent assistants. The above concise description in the inventor's own words will give our readers a clear understanding of the principles that underlie his interesting invention, and it only remains for us to describe in brief the several figures in our front-page engraving.

Fig. 1 shows the telephone in actual use, the transmitter being secured to the wall, the battery and induction coil being placed in a box on the floor, or in a convenient closet. Fig. 2 is a perspective view of the new receiver; Fig. 3 a face view of the same, with a portion of the casing broken away to show the connection of the two binding posts, A B, with the diaphragms, C D, and the adjusting screws by which the distance between the diaphragms is regulated are shown in the sectional view, Fig. 4.

Fig. 5 illustrates the principle of electrical attraction upon which the action of the new receiver is based; the electrostatic charge received by the plate, E, from the induction coil attracts the pith ball suspended in front of the plate.

Fig. 6 shows the two plates, E, of an Epinus condenser, placed near together and connected with the terminals of the secondary wire of the induction coil, I, and used as a telephone receiver.

Fig. 7 shows an induction coil with a separable primary for illustrating the principles of electrical induction.

Fig. 8 illustrates the manner of securing telephonic communication through ordinary medical electrodes.

Fig. 9 illustrates the essential features of the new telephonic system. I being the induction coil whose primary is in circuit with the battery, B, and transmitter, T; the receivers, R, are each connected with a single terminal of the secondary wire of the coil, I.

Fig. 10 shows Professor Dolbear's experimental telephone transmitter. In this instrument the diaphragm, A, is horizontal, and carries a carbon electrode, upon which rests a movable carbon electrode connected by an arm with a delicately pivoted bar supported by the diaphragm cell. The local circuit is from the battery, B, through the carbon electrodes, and through the primary of the induction coil, I.

Fig. 11 shows the exhibit prepared for the Paris Electrical Exhibition, and intended to represent the perfected telephone system. It shows two similar instruments, which in practice are placed at opposite ends of the telephone line. T is the transmitter, B the battery, I the induction coil, R the receiver, and G the ground. *b* is a key for cutting out the receiver when it is desired to talk, *d e* are the primary wires, *f* the secondary wire leading to the key, *h* the line connection of the receiver, and *i* is the ground connection of the receiver.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR ET AL.

ON MOTION FOR INTERLOCUTORY INJUNCTION.

EVIDENCE FOR DEFENDANTS.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE COMPANY
v.
AMOS E. DOLBEAR ET AL.

AFFIDAVIT OF AMOS E. DOLBEAR.

AMOS E. DOLBEAR, of lawful age, being duly sworn, says, —

I am one of the defendants.

I am professor of physics at Tufts College, and have been since 1874. I have devoted my entire time to the study and teaching of physics since 1868, and for the past twenty-five years have been a constant student of electric and acoustic phenomena.

I believe I fully understand the various methods of and apparatus electrically reproducing sound now known, and the physical laws underlying them.

I adopt the exposition given by Professor Cross of the theory of sound in his affidavit, remarking, however, that Helmholz' theory was demonstrated and published as early as 1859, and was widely known both in Europe and this country before 1860.

Electricity is a physical condition of matter which is capable of manifesting itself in two ways: *first*, by attracting neighboring bodies; *secondly*, by distributing itself with great velocity throughout some substance. In the former case it is said to be electrical *attraction;* in the latter case it is said to be a *current* of electricity. In the former case it is necessarily at rest, and its energy is potential energy, and it is called static electricity; in the latter case it is necessarily in motion, and its energy is kinetic energy, and it is called dynamic electricity.

That a current of electricity traversing the coil of an electro-magnet would induce in the coil magnetism, the polarity of which varied with the direction of the current, and the strength of which varied with the strength of the current; and that a metallic plate or diaphragm set up within the magnetic field of such a coil would give out sounds by reason of its vibrations towards the magnet in obedience to magnetic attraction, and away from it by its own resiliency, and that such vibrations would produce in the adjacent air sounds corresponding in pitch with the rate of variations in the strength of the current traversing the coil of the electro-magnet, was well known before the date of Professor Bell's patent of 1876, in suit in this case, or, so far as I am informed, of his invention described in that patent. Reis (to speak only of such results produced and published by him as I suppose to be not controverted) had done this, employing a transmitting diaphragm which was set in vibration by the impact of the air-waves produced by the utterance of speech against it, and whose vibrations caused variations of strength of current in an electric circuit which included an electro-magnet at a receiving station, such variations of strength of current corresponding in rate to the said air vibrations, and in turn inducing in the receiving electro-magnet corresponding magnetic variations, which again, by the vibrations of a metallic plate in the magnetic field, were converted into air-waves similar in rate to those produced at the transmitting station, thus producing sounds of similar pitch to those uttered at the transmitting station. This instrument is said to have been incapable of transmitting speech, because, as is alleged, the electric circuit was not constantly under the control of the moving part of the transmitter, but was at times broken by the movement of the transmitting diaphragm. And it is also alleged that the Reis receiver was not adapted to reproduce from the conducting circuit, even if his transmitter has been adapted to produce upon it, all the variations involved in the telegraphic transmission of speech.

I will assume that this is a correct summary of the results accomplished by Reis. So assuming, it appears that by means of the vibration of a diaphragm under the influence of air-waves produced by speaking, he produced certain variations of current in an electrical circuit, which variations of current were converted into corresponding variations of magnetism, which produced corresponding vibrations of a plate, whose action upon the air produced sounds similar in pitch to those uttered at the transmitting station.

The method here employed of using electricity for telegraphing sound, namely, by producing variations in a *current* of electricity traversing the coils of an electro-magnet in which corresponding magnetic variations were induced, was the only way known at the date of Bell's patent in which electricity could be made to cause mass vibrations of a plate, and so give out a definite tone.

The Bell telephone described and represented in the Bell patent of 1876 is based upon and makes use of this same property of electricity, by which a *current* of it can be converted into *magnetism*, which may then serve as the agent to cause the necessary vibrations of the diaphragm sensitive to magnetic attraction at the receiving station.

I feel sure that Mr. Bell did not know, nor did any one know, that electricity not converted into magnetism, but static and acting by its potential energy, could be used to produce such vibrations of a diaphragm, or indeed any continuous vibration at all.

This is a discovery of my own, made since Bell's patent, and upon which my method of telegraphing speech is based.

Professor Cross, in his affidavit filed in this case, says that it was well known before the date of Bell's patent that "the attractive "power of one plate on another varied with the electrical condition "of the first." This is true.

Next he says, "It was also well known before the date of said "patent that *by this means* the electrical variations in the secondary "circuit of an induction coil could be made to cause such *vibratory* "*motion in a plate* as to thereby produce a sound whose pitch cor-"responds to the rate of the electrical variations." If this means mass vibration of a plate or diaphragm or any such thing, produced in it by means of electric variations in the terminal plate, or, in other words, by means of variations in the electric potential of such a plate, I can only say, in the absence of any specification by Prof. Cross of the patent or publication or other reference he has in mind, that I know of no such thing existing before Bell's patent, or before my own discovery, and I believe that he is in error.

He goes on to say, "And this device for converting electric "variations into sound-waves was well known as an equivalent and "substitute for the motion given to a vibrating armature by means 'of the varying attractions of an electro-magnet through whose "coils the same varying current should be passed." In this I have no doubt that he is in error. I have had occasion to exhibit my telephone to a great many skilled electricians, and without exception they have expressed their astonishment at hearing that variations of the electric potential of a terminal plate could practically produce any sound vibrations of an opposed diaphragm comparable to those produced by the varying attractions of an electro-magnet.

I reproduce speech in my telephone by means of variations of the electric potential of a charged condenser. Up to the time of my invention, what was known as to the production of sound by condensers or opposed plates was very meagre. It had been observed that a condenser, when discharged suddenly, gave out a short sound, and a Reis transmitter had been used in the primary circuit of an induction coil with a condenser in the secondary circuit to reproduce pitch by the sudden discharges of the condenser rapidly following one another, being the experiment referred to in Mr. Pope's affidavit in this case. This was the most advanced stage of knowledge, so far as I know or have any reason to believe, until after 1876. The sound obtained from the discharges of the condenser as just mentioned was not obtained by any vibration of either plate of the condenser produced by the change of potential of the plates, but was obtained by the disruptive discharges of electricity from one plate to the other. Such a mode of producing sound cannot possibly be extended to the production of anything but pitch.

The discovery upon which my method of telegraphing speech is based was made by me while experimenting with a telephone based upon the principle that a current of electricity will. decompose a compound chemical substance; in these experiments I put the substance to be decomposed between two plates, the terminals of an induction coil of about 2000 ohms' resistance; and during these experiments I was surprised at hearing speech on one occasion where air only was between the plates, and when it was clear to me that there could have been no discharge from plate to plate. This led me to experiment further, and these experiments resulted in my present method and apparatus.

I believe it to be broadly true that before my discovery it was unknown that *variations* in the potential of a terminal, as distinguished from sudden discharge, could be used for my purpose, and I believe that I was the first to use them for any purpose. For example, I have discovered that the potential of a plate will give it, or a plate opposed to it, motions exactly corresponding to the changes in potential, whether the potential be increased during all of a certain period of time, whether with regular or with varying rates, or decreased during a certain period with regular or with varying rates, or both increased and decreased with rates regular or constantly varying. The fact that a condenser will give out a sound when suddenly charged or discharged has no relation to the fact that sound-waves can be produced in air by varying the potential of a plate opposed to some other body. It is not possible in the nature of things to produce speech by charging and discharging a condenser, no matter how it is done, for the discharges are practically instantaneous, and the sound-waves of speech require definite times.

There are necessarily some resemblances between Mr. Bell's method and mine, because both are methods of telegraphing speech.

He throws upon an electric circuit variations like those which the utterance of a sound has produced in the air, and the same is true of my telephone. This is a physical necessity of the use of electricity at all for the purpose of transmitting speech. There must be electrical variations of some sort on the wire, and the electrical variations (whatever they are) must correspond with those which the voice has produced in the air. Unless these things are done, the use of electricity for the purpose of transmitting speech is physically impossible. I assume, then, in comparing Mr. Bell's method of telegraphing speech with my own, that some identity beyond this must be found, if they are to be regarded the same in principle.

It is true that by Mr. Bell's method the air-waves produced in speaking are caused to vibrate an instrument which holds the electrical circuit under its control constantly, so that whatever movement of the diaphragm at any instant may be made, will be converted into a corresponding electrical variation on the line wire. And I do the same. But I consider that the two methods are nevertheless substantially different, because the electrical variations in the two cases are wholly different in character, those used by me being static or potential variations, which were not known or supposed to be available as an agent for inducing vibrations of a diaphragm, and which, when used for that purpose, do so in an essentially and radically different manner from that in which the electrical variations act which are employed by Mr. Bell.

He converts his electric variations into magnetic variations, and so vibrates the receiving diaphragm by a property of both which was well known; and he is able to effect this conversion because he uses the dynamic or kinetic energy of electricity traversing a coil; in other words, his electric variations are variations in an electric current.

I do not convert my static electric variations into magnetic variations, because they are static and not dynamic. I use them directly and without change, to effect the vibration of the receiving diaphragm. The possibility of so using static electric variations, or variations of electrical potential, was not known until I discovered it.

The two methods of telegraphing speech are, I truly believe, essentially and radically different, based upon different electrical laws; based, in my case, upon an original discovery of a capacity or power of electricity not previously known or believed to exist, *i. e.*, the power of electricity acting through its static or potential form to attract, according to variations of its electric potential, a body electrified to a different potential, and to thus produce sonorous vibrations.

When speech is transferred from one place to another electrically, whether by a known method or one not yet imagined, it is perfectly certain that the sound at the transmitting station must so act as to cause the electric energy upon the line to vary in its strength with the varying phases of the sound to be reproduced, because the problem is to reproduce one form of energy by converting it into a second form of energy; that is, air vibrations into electric vibrations; and it is a truism that the electric vibrations must conform to the air vibrations which produce them, if the electric vibrations are to be used to produce air vibrations like the first. Let me speak of it, for this purpose, as form of energy A. Now A is not electricity, and if electricity is to supplant A, A either must be transformed into electricity or be applied in some way so as to modify a current of electricity or an electrified body, so that any phase of A shall have its counterpart in electricity, for the latter is the agent to do the work at the receiving end. So much is inevitable, and due, not to invention, but to the physical laws involved. The methods for doing this are proper subjects of invention.

Now, electricity is a form of energy also; call it E. If form of energy A′ is to be like A, and is to be produced by E going from A to A′, it is a physical necessity that E must conform in all particulars to A, so that every phase of A shall have a corresponding phase in E; for nothing can be produced at A′ except by the various phases of E.

That these conditions which are employed in the telephone involve what is known as the conservation of energy, and are mathematical in their nature, is allowed and must be allowed by any one understanding them.

I will now compare my method and apparatus more in detail with those described in the Bell patent.

As to the method: Considering figs. 5, 6 and 7 in the light of the description of Bell's method, I have no doubt that Bell's method of reproducing sounds consists in (1) converting the energy of sound-waves into magnetic variations; (2) converting these magnetic variations into electric variations; (3) reconverting these electric variations into magnetic variations; and (4) reconverting these last magnetic variations into new sound waves; each one of these transformations being an example of the conversion of one form of energy into another form, according to the well-known laws of the conservation of energy and correlation of forces.

The apparatus for employing this method consists of (1) a device which is operated by the energy of the sound-waves; (2) a magnetic system, the energy of which is varied by the operation of this device; (3) a conductor circuit in which electric energy is set up by the variations of the magnetic energy of the first magnetic system; (4) a second magnetic system, the magnetic energy of which is varied by the variation of the electric energy in the conductor circuit; and (5) a device which is operated by the variations of magnetic energy in the second magnetic system to reproduce sound-waves. My method differs from Bell's (if the above be taken as Bell's) in these respects.

I use the energy of the sound-waves to control the electricity in a circuit, instead of converting that energy into magnetic variations, as Bell does; and this difference is very important practically, for the reason that all the magnetic energy Bell can get, can never exceed, and practically must fall much short of, the energy of the sound-waves, which is itself necessarily weak; while in this part of my method (which is not mine, but borrowed from Reis) the electric energy has no relation to the energy of the sound waves, but the electric energy used is very many times greater than the energy of the sound-waves; and this because the energy of the sound-waves is not converted into another form of energy, as in Bell's method, but is employed solely to regulate the supply of electric energy; the difference being much the same as between turning a wheel by hand, thereby converting muscular power into motion, and moving water-gates by hand, thereby giving motion to the wheel. This electric energy I convert into magnetic variations, but it is the fact that any magnetic variations which can be practically obtained by converting the energy of sound-waves is wholly inoperative in my system; for my receiver will not work practically, if at all, with a magneto-transmitter. But even assuming that I do convert sound-waves into magnetic variations, and therefore must be held to employ the first step in Bell's method, how is it as to the second step? It is true, in some sense, that I convert these magnetic variations into electric variations; but it is the fact that the electric variations utilized in my method are radically different from those used in Bell's method. In Bell's method variations in current strength are essential, while in my method the electric variations are static. I use magnetic variations solely to obtain great variations in potential or charge, not to obtain variations in current strength. In Bell's method, the greater the variations in current strength the better the result; in my method current variations are not utilized.

In Bell's method, Ohm's law, — *i. e.*, electro-motive force, divided by resistance, equals current strength, — is applicable to the electric variations; while that law has no application whatever to the electric variations used in my method.

To make this clearer, suppose a soft-iron core surrounded by a primary and secondary coil. So long as the current strength of the primary circuit is constant, the magnetic strength of the soft-iron core will be constant; but upon any variation of the current strength in the primary circuit, the magnetic strength of the soft-iron core will vary proportionately; and instantaneously with each and every variation of the magnetic strength of the core, the secondary coil will become electrified, one end being positive, the other negative; that is, the ends will be at different potentials; and their potentials will vary instantaneously, at each and every variation of the current strength in the primary coil, and there will be no current, but simply electric tension or electric pressure in the secondary coil. The energy is potential only, not kinetic; while in all currents of electricity the energy is kinetic and not potential. The two names for these electric conditions are static and dynamic.

The ends of the secondary coil, when the coil is electrified, will attract each other, and the force of that attraction will vary directly as the electric tension or potential varies, other things being equal.

Enlarging the surface of either one of the ends will very greatly increase its attractive force, the increase in force being directly as the increase in surface, supposing the tension to be the same until the terminal receives its maximum charge.

It is this quality of electric variations, viz., variations in electric tension or electric pressure or charge, into which the energy of the magnetic variations is converted in my method, while in Bell's method the energy of the magnetic variations is converted into vibratory currents. The difference between us in this respect is almost precisely the same as the difference between the energy of a varying current of water and the energy of a varying head of water. It is impossible to apply the electric energy active in Bell's method to work my receiver, and impossible to apply the electric energy active in my method to work Bell's receiver; and this to my mind emphasizes the difference I am now dealing with, which is, that although it is true in a sense that we both convert the energy of magnetic variations into electric energy, yet it is clear to all skilled in this art that the electric energy into which I convert the energy of the magnetic variations is a wholly different electric energy from that into which Bell converts the energy of magnetic variations; at least as different as the kinetic energy of a given number of cubic feet of water flowing from one point to a lower one in a given time is different from the potential energy of a column of water with no outlet, and so different that all will agree that it is physically impossible to utilize the potential energy of electric variations in Bell's method, and equally impossible to utilize the kinetic energy of electric variations in my method.

The above considerations of the second step of Bell's method applies in a measure to the third step which in Bell's method consists in converting the energy of electric variations into magnetic variations.

This I omit wholly. I convert the potential energy of my electric variations directly into motion, while Bell converts the kinetic energy of his electric variations, first into magnetic energy, and that into motion. This part of my method, viz., the direct conversion of the potential energy of electric variations into sound-waves of all characters, is, so far as I know or have any reason to believe, a new discovery. I discovered it, as I have stated, almost by accident, and while searching for a wholly different matter; and up to that time the knowledge on the question of the production of sound by condensers, or opposed plates not in contact, was very meagre, as I have before stated, and what was known tended strongly to show that such plates were not at all adapted to reproduce anything but pitch.

The following facts were all well known before 1876; viz., that an electrified body would attract all other bodies, except such as were electrified with like electricity; that two electrified bodies would repel each the other if both positively or both negatively electrified, and would attract each the other if one were positive and the other negative; but I am not aware of any methods or apparatus utilizing these facts before my discovery and invention, except only electrometers and like instruments in which two plates or leaves are charged with like electricity and therefore repel one another, or in which a suspended body, as a pith-ball, is caused to move by being electrified. I have no doubt that I was the first to discover that variations of charge (which is precisely the same thing as variations of potential, or of electric pressure, or of electric tension, and a wholly different thing from variations of current) could be used to produce any desired effect.

Taking the above view of Bell's method, his apparatus is, in essence, two magnets, two armatures, two coils and a conductor circuit of which both coils form a part. My apparatus, as most commonly used, consists of a primary circuit, containing a transmitter, a battery and a primary coil, a magnet within the primary coil, and also within a secondary coil, with the terminals of the secondary coil enlarged and opposed. It is obvious, therefore, that my apparatus lacks the magnet and its coil and armature which are in Bell's receiver. It is also the fact that the construction and operation of the coil and magnet which I use differ widely from the transmitting coil and magnet of Bell's apparatus, because my secondary coil must be of very high resistance, say upwards of 2000 ohms (and better 5000 than 2000) to produce a sufficiently high charge in the secondary coil, while the transmitting coil of Bell's apparatus is in practice only a slight resistance, say about 150 ohms, and inoperative with my receiver, although especially adapted for Bell's receiver, because Bell's receiver works to the best advantage when the transmitting coil is such as to produce that current best adapted for the coil and core of the receiver; anything in excess is not only wasted, but hurtful. The resistance of the transmitting coil is an example of internal resistance, while that of the receiving coil is external resistance, and it is perfectly well known that for the maximum effect the internal and external resistance should be equal.

This, to my mind, also throws much light upon the absolute difference between my method and apparatus and that of Bell; for in my case the internal resistance should be about 5000 ohms, and may well be very much greater; but the external resistance is many millions of ohms, practically infinite; and if the internal resistance in my case should equal or exceed the external — which is practically impossible — my apparatus would not work, because sparks would pass rapidly between the plates, and destroy its action as a receiver.

Bell's method and apparatus may be considered as follows: Bell's method may consist in (1) regulating a continuous voltaic current by the energy of the air-waves; (2) converting the energy of this regulated current into magnetic variations, and so on as before. His apparatus, in this point of view, will consist of a primary circuit containing a transmitter, a battery, and a primary coil substituted for the transmitting armature of his apparatus as at first considered.

Taking this view of Bell's method and apparatus, my method and apparatus is the same in substance so far as concerns the primary circuit, with a transmitter, battery, and primary coil in it, as the like parts of the assumed Bell method and apparatus. But all that I have said as to the vastly different electric variations in the secondary coil, and the wholly different method of utilizing them, remains, of course, equally applicable here.

Lastly, Bell's method and apparatus may be considered as follows: Bell's method may consist in (1) regulating a continuous voltaic current by the energy of the air-waves; (2) converting the energy of this regulated current into magnetic variations; and (3) converting these magnetic variations into sound-waves, or precisely what Reis tried to do. His apparatus, in this view, will consist of a line conductor circuit, containing a transmitter, a battery and a coil, a magnet in this coil, and an armature controlled by it. In this view, I have a conductor circuit, a battery and a coil, with a magnet in the coil, but lack the armature, and also lack any equivalent or known substitute for the armature. And my method, while the same as the assumed Bell method, so far as concerns regulating a voltaic current by the energy of the air-waves, and converting the energy of this regulated current into magnetic variations, is yet wholly different in all other respects from the assumed Bell method; for magnetic variations are wholly inoperative upon my receiver until they are converted into the electro-static variations which I have fully described. Moreover, the electric variations utilized by me, and which I have no doubt are wholly new with me, are widely different from any electric variations in the assumed Bell method and apparatus, as I have above fully explained.

The practical advantages of my method and apparatus over Bell's, whichever one of the three views above mentioned may be taken of Bell's, are: *First.* The very high potential or electric tension which is the essential and most striking feature of my electric variations practically remedies all the very serious ill effects arising in all other telephones from induced currents and earth currents; and the reason of this is that the tension of such currents is very trifling compared to the electric tension necessary to operate my receiver; although the strength of such currents is amply sufficient to seriously interfere with the operation of any other receiver known to me, even on short lines, and is fatal in lines of any great length.

Secondly. On account of the very high tension of my electric variations resistance in the line is of no practical importance; while it is of very great practical importance in all telephones which operate under Ohm's law.

My discovery that electric variations of extremly high and varying tension were adapted to produce vibrations of all qualities, enables speech and all other sounds to be readily transmitted over very much greater distances than with any other telephone, and under circumstances (such as earth currents, proximity of other wires, &c., &c.) where any other telephone would be inoperative.

These two difficulties, viz., restricted length of line and disturbances from earth currents and induction, were ascertained by experience several years ago, and are problems a solution of which is of the gravest importance.

There are other practical advantages of my method and apparatus over Bell's, but second in importance to the very great advantages above mentioned. These are, that very many of my receivers can be used on one wire, which is practically impossible with Bell's; there are no fine wire helices in my receivers which are in constant danger of destruction in Bell's from atmospheric and electric-light currents. The simplicity and durability of my receiver is also advantage.

To sum up: Assuming that Bell's method includes all methods of reproducing speech in which electricity is the agent, then it certainly includes my method. Assuming that it includes all methods of reproducing speech in which the phases of the electricity used correspond with the phases of the sound-waves, it also includes my method, and must necessarily include all methods in which electricity is used; for it is physically impossible for electricity to do the required duty unless it so corresponds with the sound-waves generating or controlling it. Assuming that it includes all methods in which the electricity generated or controlled by the sound-waves is utilized by any means known at the date of Bell's patent for utilizing it, *e. g.*, by its magnetic, chemical or heat effects, then it does not include my method, for the electric variations utilized in my method are static, not dynamic, and cannot produce any of the effects above named, and the effects of rapid variations of potential had not been discovered until I discovered them.

Assuming that Bell discovered that a rapidly varying current of electricity traversing a helix within which was a magnet would cause the armature of that magnet to reproduce the air-waves by which the current was caused to vary, it is yet true that he did not discover that rapidly varying the potential of two opposed plates would reproduce the sound by which such potential was caused to vary; and while it is true that it was known to students before the date of his patent that the potential of the ends of an induction coil must vary with every variation in the current which traversed the primary circuit, yet no practical use had ever been made of this knowledge except to charge the terminals of the coil sufficiently to produce a discharge between them; and there was no reason to believe, so far as I know, before my discovery of the fact, that rapid variations of charge could be used to produce sound-waves.

A. EMERSON DOLBEAR.

UNITED STATES OF AMERICA,

DISTRICT OF MASSACHUSETTS, COUNTY OF SUFFOLK, } ss.

Subscribed and sworn to at Boston in said district this sixth day of January A. D. 1881.

Before me,

[SEAL] J. HENRY TAYLOR,
Notary Public.

AFFIDAVIT OF FRANK L. POPE.

FRANK L. POPE, of lawful age, being duly sworn, says, —

My name is Frank L. Pope; age forty-one; I reside in Elizabeth, N. J., and am a solicitor of patents. I have been a working electrician and electrical engineer for more than twenty years, and am familiar with the construction and operation of nearly if not quite all the different kinds of telegraphic and electrical apparatus in practical use. From 1875 to 1880 I was employed by the Western Union and Gold & Stock Telegraph Companies of New York city as an expert, my particular business being to examine and report on the novelty, utility and patentability of the various inventions which were constantly brought before the officers of these companies for adoption; and also to advise in a general way upon all matters of that character. I have been acquainted with the speaking telephone since the summer of 1877, and was familiar with descriptions of the same which were published prior to that time. In August, 1877, I made a thorough examination of the whole subject of harmonic telegraphy up to that date, including the speaking telephone, and from that time until the present have endeavored to keep myself informed as completely as possible of everything that has taken place in the way of developments and improvements of the original inventions.

I have carefully read the patent of Mr. Alexander Graham Bell, viz., No. 174,465, dated March 7, 1876, and believe that I understand the invention therein described. I understand the apparatus known as the Bell speaking telephone, and the method by which the same is operated, to constitute the subject matter of the fifth claim of said patent, which claim is as follows: —

"The method of and apparatus for transmitting vocal or other " sounds telegraphically, as herein described, by causing electrical " undulations similar in form to the vibrations of the air accompany- " ing the said vocal or other sounds, substantially as described."

The *method* of transmitting vocal or other sounds over a telegraph line which is described in the specification of the patent, consists in causing the vibrations of the particles of air which necessarily accompany the production of a sound, to impart a mechanical movement of like character to a body so constructed as to be capable of being thrown into corresponding vibrations. By the movements of this body an electric current of varying strength, which the specification calls an undulatory current, is produced at the transmitting station in a continuous circuit of electrical conductors, which includes the coil of an electro-magnet at the receiving station. This varying electric current induces magnetism in the core of the said electro-magnet, the intensity of which varies in proportion to the strength of the inducing current. The armature of this electro-magnet is attached to, or consists of, a resonant plate or diaphragm, which, when subjected to the varying attraction of the magnetized core, is thereby thrown into vibrations, which are mechanically communicated to and taken up by the air-particles in its vicinity, thus producing at the receiving station vibrations of the resonant plate like those of the vibrating portion of the transmitter, and these vibrations being communicated to the air particles reproduce (although with diminished intensity) the original sound first produced at the transmitting station. The method described therefore comprises the following series of successive steps or operations: —

1. The communication of physical motion from the air to the

transmitting diaphragm. 2. The production of electrical undulations in the conducting circuit by the motion of the diaphragm. 3. The production of varying degrees of magnetic intensity in the core of an electro-magnet by the action of an undulatory electric current traversing its enveloping coil. 4. The production of physical vibrations in a resonant plate by the varying magnetic attraction to which it is subjected by the said electro magnet. 5. The production of sonorous vibrations in the atmosphere by the physical vibrations of the resonant plate.

The *apparatus* described in the specification by means of which the foregoing method is to be carried into effect, consists of a body capable of responding to sonorous vibrations in the atmosphere, that is to say, of taking up from the atmosphere the same character of vibration, which body acts inductively to vary the magnetic intensity of an iron core surrounded by a coil of wire, whereby magneto-electric currents are set up in the coil, the duration and force of which are determined by the rapidity and extent of movement of the inducing body in the neighborhood of the core. A continuous circuit of electric conductors extends from the transmitting to the receiving station, and includes the coil of the transmitter as well as the coil of another electro-magnet which forms the most essential part of the receiver. The armature upon which this electro-magnet exerts its attraction is affixed to, or is formed by, a resonant plate or diaphragm.

Hence the *apparatus* which is described in the patent consists substantially in a combination of the following elements: —

1. A vibrating armature or inductor capable of responding to sound vibrations.

2. An iron core surrounded by a coil of wire, the magnetic intensity of which core is varied by and in accordance with the movements of the inductor or armature.

3. An iron core surrounded by a coil of wire, the magnetic intensity of which core is varied by and in accordance with the strength of the electric current passing through said coil surrounding the core.

4. A continuous electric conductor or series of conductors forming

a circuit which unites the transmitting and receiving stations, and which includes both the coils hereinbefore mentioned, and by means of which the currents induced by one core are made to act upon the other.

5. An armature which is capable of responding to all the different degrees of attractive force produced by the varying magnetic intensity in the core of the receiving magnet, and of communicating corresponding physical vibrations to the air.

The specification states that means of producing an undulatory electric current may be employed other than the one specifically described and illustrated, which consists in vibrating an armature or inductor in the vicinity of the pole or poles of a magnet, several known methods of effecting this being particularly named. In practice a means of varying circuit resistance is almost universally used to vary the magnetic energy of the iron core by which the undulatory currents are induced in the line; viz., that of placing an auxiliary, or in technical language a "primary," coil of wire upon the inducing core, through which primary coil a continuous voltaic current is made to pass, the strength of which is varied by means of a variable resistance, the latter being in turn controlled by the vibrations of the diaphragm or body which is set in motion by the air-waves. The variable resistance, the continuous voltaic current and the primary coil, used in this system, together constitute an equivalent for the vibrating inductor used in the system shown in figures 5 and 7 of the patent, and when substituted therefor produce a similar but much more powerful effect.

The general result which is produced by the method and apparatus described in the patent, is the production at the receiving end of a sound similar to, but of less intensity than, the original sound at the transmitting end by which the apparatus is set in action. The receiving diaphragm, however, does not reproduce all the motions of the transmitting apparatus with absolute fidelity. In the conversion of magnetism into electricity, and electricity again into magnetism, a certain change in the form of the vibrations takes place which is due to what is termed the magnetic inertia of the iron core. The mass of iron requires a certain definite length of time either to receive or to part with its magnetism, and as some of the variations in the strength of the current take place with great rapidity, the full magnetic effect due to the particular strength of current at any given time is not always attained, and hence a strict proportionality between the more and less rapid series of vibrations is not always preserved. From this cause doubtless arises the observed fact that certain sounds and particular words of which those sounds form essential elements are understood with difficulty.

I am acquainted with the speaking telephone apparatus invented by Professor Dolbear; have frequently examined the same, and am familiar with its construction, principle and mode of operation. This apparatus is similar to that described in the affidavit of Edward Davis in behalf of the complainants in this motion, and illustrated in the drawings and diagrams accompanying said affidavit, subject, however, to the following reservation; the description given by him of the circuits, so far as it involves the suggestion, either expressly or by implication, of the passage of any electric current through the receiver to earth or to line, is erroneous, as the diagrams show, and I have satisfied myself by actual examination and experiment that such passage of any electric current is precluded by the theory of Professor Dolbear's method and the construction of his apparatus.

The method of transmitting vocal or other sounds over a telegraph line which is employed by Dolbear, resembles that described in the patent of Bell, in so far as the process of producing variations in the magnetic condition of the iron core of the inducing magnet at the transmitting station is concerned. That is to say, these variations of magnetic energy are controlled by and are correlative with the vibrations of the air-particles which are there taken up by the diaphragm or other body. But here the resemblance ends. The process of transferring this action by means of electricity to the receiving station, and of causing at that point the vibration of a resonant plate whereby the sounds are reproduced, is radically different.

Bell's transmitter sets up a varying electric *current* in a continuous circuit of conductors, while Dolbear's transmitter sets up a varying electric *potential* in a linear conductor which does not form a circuit at all. The varying current in the circuit, according to Bell's method, traverses the coil of an electro-magnet at the receiving station, is converted into magnetism, and again converted from magnetism into mechanical motion, which produces sound. The varying potential in the linear conductor, according to Dolbear's method, gives rise to a corresponding electrical attraction between a part of such linear conductor and an adjacent surface, electrified to different potentials, which electrical attraction directly produces mechanical motion, which in its turn produces sound.

The two methods, in short, avail themselves of two wholly distinct properties of electricity, or two wholly distinct electric energies, namely, the so-called *dynamic electricity* employed in Bell's system, and *static electricity* employed in Dolbear's system. These energies differ, *first*, in their *intrinsic natures*, and *secondly*, in the *effects* they are capable of producing. As regards their natures, the essence of the dynamic electricity is its *motion*, and the essence of the static electricity is its *rest*. Hence their respective names. As regards their effects, each produces a manifestation of energy wholly different from that produced by the other. Dynamic electricity, by virtue of its motion, produces magnetism. Static electricity, by virtue of its lack of motion, produces electrical attraction. These effects, as widely different as the causes which produce them, are respectively used by the two systems. A uniform and continuous *magnetic* attraction can only be produced from the conversion of electric energy by means of a continuous electric current traversing an uninterrupted circuit. If this circuit be interrupted, the magnetic attraction ceases. On the other hand, a uniform and continuous *electric* attraction can only be produced from the conversion of electric energy by means of a continuous difference of potential, which is maintained by a continuous interruption of the conductor. If the circuit be closed, the difference of potential is no longer maintained and the electric attraction ceases. The property of electricity whereby it exerts a direct attractive force is said to have been discovered by Thales about 600 B.C., while the property whereby it is enabled to exert an attractive force through the intervention of magnetism was first observed by Romagnesi about the year 1805, and afterwards by Oersted in 1819.

The substantial difference, therefore, between the two methods, I find to be this: Bell makes use of variations in the strength of an electric current traversing a continuous circuit to produce magnetic variations, which by their varying attractions produce mechanical vibrations, which in turn produce sound; while Dolbear make use of variations of electrical potential in a linear conductor, which variations directly cause varying attractions, and these produce mechaniical vibrations, which in turn produce sound; or, to state it more briefly, in the one case there is an indirect conversion of one form of electric energy into mechanical motion through the intervention of magnetism, and in the other case the direct conversion of another form of electrical energy into mechanical motion without the intervention of magnetism or any other form of energy. Hence one essential step of the method set forth in the patent is altogether omitted.

The apparatus of Dolbear consists of an indueing magnet at the transmitting station surrounded by a coil of wire which is continuous with the linear conductor. The core of this magnet is provided with an auxiliary coil, a local battery producing a constant voltaic current, a varying resistance, and a diaphragm or other body to respond to the movement of the air-particles, which diaphragm through the intermediate action of the parts just mentioned acts to vary the degree of magnetic energy in the inducing core. Thus far the apparatus of Dolbear is substantially the same as the apparatus which is employed in the telephones in general use.

The apparatus at the receiving station, however, is radically different from that of Bell in its construction, principle and mode of operation. Instead of a continuous conductor passing around an electro-magnet and forming a closed circuit, there is a linear conductor which begins with the induction coil and terminates at the receiving station in an insulated metallic plate, forming an enlargement or expansion of the end of the conductor. Facing this plate, but separated therefrom by a non-conducting air space, is another insulated metallic plate, so mounted as to be capable of responding to the varying electrical attractions of the first plate, and thereby producing sounds. The resonant plate need not be connected with the earth nor with any return conductor, because no use is made of any electric current traversing a circuit. This is a new way of using electricity as a means of transmitting sound.

It was well known prior to the date of Bell's patent that the direct attractive force exerted by one body upon another is in proportion to the difference in electric potential existing between them. It had also been observed that when thin sheets of metal are superposed and separated from each other by an intervening sheet of paper, and the plates thus arranged are respectively placed in connection with the opposite terminals of a coil surrounding an inducing magnet, each interruption of the circuit of a primary coil surrounding the same magnet will produce an instantaneous change of potential in the terminal plates sufficient to cause a disruptive discharge from one plate to the other through the intervening sheet of paper. This discharge is accompanied by a spark and by a peculiar sharp crack or snap. When this discharge occurs regularly and with sufficient frequency the succession of cracks or snaps thus produced assumes a rhythmical character, and become a simple musical tone, the pitch of which depends upon the rapidity with which the separate discharges occur. A somewhat analogous phenomenon was noticed by Sir William Thomson in the case of the sudden charge or discharge of the well-known Epinus condenser. He observed that when the condenser was charged from a reservoir of electricity (the particular form employed by him being a submarine telegraph cable charged to a high potential and constituting a Leyden jar of enormous capacity) a sound was heard so closely resembling the snap of a disruptive discharge that his ear could not distinguish between them. He noticed the same sound also when the condenser was discharged.

There was nothing whatever in the character or nature of the sounds produced by Sir William Thomson in the Epinus condenser, or that accompanying the disruptive discharge in the experiment where the alternate sheets of metal and paper were employed, or in the method by which the sound in either case was produced, that could in any way suggest the utilization of such a sound so produced for the intelligible reproduction of human speech. The sole result of the repetition of the sound in either case would be merely a tone which could be varied in pitch, but whose character or quality would always remain that of the snap or crack, more or less frequently repeated. Certainly in the operation of the Dolbear apparatus no such sound is audible, and to just the extent that it did occur it would impair the operation of the instrument, by drowning or confusing the other sounds by which the speech is made audible.

Prof. Cross, in his affidavit filed on this motion, says that it was well known before the date of the Bell patent that by means of the attractive power of one plate on another, varying with the electrical condition of the first, the electrical variations in the secondary circuit of an induction coil could be made to cause such vibratory motion in a plate as thereby to produce a sound whose pitch corresponded to the rate of the electrical vibrations. I think he is mistaken. I know of no such thing before the date of Bell's patent.

So far as my knowledge goes, it was not known prior to the discovery of Dolbear that the varying attraction of an electrified body would cause a plate, capable of mass vibration and having a different potential, to vibrate at all by virtue of that difference of potential, and still less that the loudness, pitch and quality of such sounds, upon which their capacity for reproducing articulate speech depends, could be made to vary in accordance with the varying potential of the attracting surface; and it is upon this physical property of an electrified body, which was originally discovered by him, that the method of Delbear is founded. All that was before known in relation to the production of sounds through the agency of differences in potential between adjacent plates, tended to show that it was impossible to produce sounds differing in any other respect than pitch or rapidity of succession, while their loudness and quality remained unchanged.

I do not find this method or process described, indicated or suggested in any manner in the specification of Mr. Bell's patent.

It is a method or process of using electricity to produce sound vibrations which was not only not known at the date of the Bell patent, but which nothing that was known tended, in my judgment, to suggest, but rather to exclude.

Speech cannot be telegraphed at all unless electrical action of some sort is made to take place which corresponds with the mechanical action of sound-waves, and which is capable of producing again a like mechanical action. This is necessarily involved in the use of electricity for this general purpose. But the two methods make use of different sorts of electrical action; one of them, that used by Dolbear, having been originally discovered by him, since Bell's patent, to be capable of such use.

The novel method of Dolbear as practised by means of the apparatus which I have described produces certain improved results of great utility, which may be summed up as follows: 1. The avoidance of interference arising from foreign currents and electrical pulsations from parallel lines which are transferred to the telephone lines by leakage or by inductive action and produce extraneous noises. There can be no leakage from another line which will affect the receiving apparatus of the Dolbear telephone, for the reason that there is no conducting circuit whereby it can pass through the receiving instrument, or otherwise affect it in any way. The differences of potential arising from the inductive action of currents traversing neighboring parallel lines are so small that they are not sufficient to perceptibly affect the receiving apparatus. 2. The correct transmission of articulate speech from the transmitting to the receiving diaphragm is greatly facilitated by the omission of one conversion of energy in which the electro-magnet is employed, viz., that at the receiving station, from which arises the fact that the articulation of certain sounds and of words including such sounds, is more full, clear and distinct. 3. The parts of the electro-magnetic receiver which are subject to injury from atmospheric electricity or lightning are entirely dispensed with. 4. The receiving apparatus is simple and cheap in its construction.

It is therefore my opinion that neither the combination of apparatus employed by the defendant for the transmission of vocal or other sounds, or the method, means or process by which said apparatus is operated, is the equivalent of that described in the patent of

Bell, inasmuch as one essential element of his combination of apparatus, and one essential step of his process, is omitted, and nothing is substituted therefor which was known as an equivalent at the date of filing the application upon which the patent of Mr. Bell was issued.

My attention has been called to the statement in Prof. Cross' affidavit, that "both the instruments [Bell's and Dolbear's] form "parts of an apparatus which, as a whole, transmits speech *by* "*means of* certain peculiar variations of electrical currents." If this means that Dolbear uses a complete electrical circuit *as part of his transmitter*, in which circuit, for the purpose of inducing magnetic changes in the transmitting core, such variations of an electrical current are employed as Bell employs in the circuit in which his receiving core is placed, the statement is correct. But I do not understand that any similarity of method in the two cases results from it.

The *transmitting circuit* employed by Dolbear, and the *vibrating inductor* employed by Bell, are corresponding elements in their respective systems of apparatus. As already mentioned, either of these elements may be used in the Bell system to produce undulatory currents, and when so used they are the substantial equivalents of each other. But Dolbear does not use either of them to produce an undulatory current. He uses the transmitting circuit to produce a variation of electric potential, and therefore, though the first element of the apparatus of Dolbear may be identical in appearance with the first element of Bell's, still the first step in Dolbear's process is radically different from the first step in Bell's process; all subsequent steps in the two processes being also radically different as heretofore explained.

FRANK L. POPE.

Subscribed and sworn to before me this seventh day of January, 1882.

WM. C. WITTER, [SEAL]
Notary Public.

AFFIDAVIT OF JOHN TROWBRIDGE.

John Trowbridge, of lawful age, being duly sworn, says, —

I am professor of physics in Harvard College, and have devoted my whole time to the study of mathematics and physics since 1865. For upwards of ten years I have devoted especial attention to electricity.

I understand the Bell method and apparatus for transmitting speech electrically, and also the Dolbear method and apparatus.

The main difference between the two systems is that one utilizes what is called dynamic, the other what is called static electricity. It was well known for many years before 1876 that a current of electricity, which is what is meant by dynamic electricity, flowing through a helix would produce magnetic effects; and the state of knowledge as to this has not been advanced at all since 1870, unless it be by what is called Hall's discovery, which has no relation to this matter. In fact, nearly all practical applications, both scientific and useful, of electricity, before Dolbear's discovery, were of currents of electricity, or dynamic electricity, and the effects were produced by the flowing of a current through a helix to produce magnetic effects, or through an electrolytic compound to produce chemical effects, or through a conductor to produce heat effects, or through animal tissue to produce physiological effects. I do not know any practical application of static electricity, that is, electricity not in motion, before Dolbear's; although I have recently seen a description of an apparatus for separating bodies of different sizes by means of electrification; and in this apparatus static electricity only is utilized. As to scientific applications, I know of none, except such as are involved in electro-static measurements.

Dolbear's system is based upon his discovery that variations of charge can be practically used; while Bell's system is based upon the well-known laws as to the production of magnetic effects by currents of electricity. One very practical difference between the two systems, viz., that Dolbear's is not injured by extraneous dynamic currents, which are always injurious to, and frequently wholly prevent, the operation of Bell's, depends wholly upon the fact that Dolbear's receiver is not affected by currents, but only by charge; while Bell's is affected only by currents.

In both the method of Bell and that of Dolbear electrical variations, corresponding in form with the air vibrations produced by the utterance of speech, are set up in the line wire. Unless this is done, it is physically impossible that speech should be transmitted by electricity. Apart from this similarity, I think it clear, for the reasons I have stated, that the two methods of transmitting speech telegraphically are substantially different, based upon different scientific principles.

JOHN TROWBRIDGE.

District of Massachusetts, } ss. Boston, December 28, 1881.
County of Suffolk, }

Then personally appeared the above-named John Trowbridge and made oath that the foregoing affidavit, by him subscribed, is true.

Before me,

[seal] WILLIAM A. COPELAND,
Notary Public.

AFFIDAVIT OF MOSES G. FARMER.

Moses G. Farmer, of lawful age, being duly sworn, says, —

My name is Moses G. Farmer; I am sixty-one years old; am temporarily residing in Boston, and am by profession a consulting electrical engineer.

Since 1846 I have been engaged in the scientific study of electricity, and practically familiar with almost if not quite all the modes of its practical application, including the electric telegraph from the time of its invention, electric lighting since 1858, and the electric speaking telephone since 1877. I have experimented with several forms of that instrument, among others those known as the "Bell,' the "Blake" and the "Edison," and believe myself to be familiar with the principle and mode of operation of those instruments, and the system or systems of electric telephony in which they are employed.

During the present month of December, 1881, in the city of

Boston, I examined, for the first time, the telephone and the telephonic system, known as those of Dolbear, invented, as I am informed, by Prof. Amos E. Dolbear, and I believe myself to be familiar with its principle and mode of operation.

The "Dolbear telephone," as I saw and tested it, consisted of a transmitter of the class known as variable contact transmitters, its form closely resembling the so-called Reis transmitter as that instrument is shown in contemporary publications, but so constructed as to be less likely to break contact under the impact of voice vibrations, and consequently better adapted to vary without actually interrupting the primary circuit in which it is placed. A portion of this circuit forms the primary coil of an induction coil, a portion of the line wire being the secondary of the same coil. A peculiar feature of this coil I found to be the unusually high resistance of the secondary coil, which was greatly in excess of that ordinarily used with the "Blake" or "Edison" variable contact transmitter.

The line wire was substantially of the sort commonly used with other forms of telephone; but I observed one marked difference between the arrangement of it and that of any other line which I ever knew of as being employed for the electric transmission of speech. This difference lay in the fact that the main line or line wire was a permanently discontinuous or "broken" circuit, in fact not a circuit at all in the sense of a return either by wire or through the earth. This peculiar construction was, as I saw, a necessary one for the operation of the receiving instrument, in which the line wire terminated. This consisted of a pair of stretched diaphragms arranged opposite each other in parallel planes, but separated by a thin intervening annulus of hard rubber. One of the diaphragms was, in all the forms of the instrument I examined, the terminal of the line wire. The other plate, which, when caused to vibrate by the electric changes of the first, produced the speech or words that had been transmitted, was variously connected in different forms of the instrument to avail of various means of increasing its electrical charge. In one form of the instrument this plate was connected with the body of the listener through the handle of the telephone. In another case the other end of the line wire was attached to this second plate. I did not observe any material superiority of action in one form over the other. In each case the articulation was clear and distinct, particularly so in the case of those combinations of sibilants which have heretofore always been found difficult to transmit telephonically.

The "Dolbear" telephone system is not in any sense a modification of that known as the "Bell" system, in which I include generally all speaking telephones that I have heretofore known. It is based upon a different property of electricity, and that different property in turn is put to a different use.

The external features of the two systems have this in common: that the speaker speaks against a vibrating body, the hearer listens near another vibrating body, and the sounds transmitted are transmitted by electricity. And these characteristics will, in my opinion, as a matter of physical necessity, be found in any apparatus that can be or will be devised for the electric transmission of speech, however widely its principle of operation may vary from any we now know. But the *kind* of electricity, or, more properly speaking, the property of electricity employed is different, the work done by it is different, and the apparatus by which it is done is different.

The laws of electrical attraction, arising from differences of potential, on which the operation of the Dolbear system depends, have been matter of scientific knowledge for many years, but the application of them to the electrical transmission of speech is not only novel, but, so far as my knowledge extends, entirely original. Unlike the principles of electro-magnetism and electro-magnetic attraction, which have been for many years under careful study, and embodied in many forms of apparatus for performing many kinds of duty, even including that of producing sound, the phenomena of electrical attraction before Prof. Dolbear's invention have been studied and investigated only in the laboratory or the lecture room, and no attempt, so far as I know, had ever theretofore been made to practically utilize that force to perform any mechanical duty whatever, except the testing of fuses.

For the purposes of producing sonorous vibrations of a diaphragm, the use of variations of electric potential cannot properly, I think, be regarded as the known substitute or equivalent of the use of magnetic variations as employed in the Bell telephone and described in his patent. The capacity of varying electric potential to perform such a duty in kind or in degree had not, I think, been demonstrated till it was done by Prof. Dolbear.

MOSES G. FARMER.

UNITED STATES OF AMERICA,

STATE AND DISTRICT OF MASSACHUSETTS, }
COUNTY OF SUFFOLK, } ss.

At Boston in said county this twenty-seventh day of December, A. D. 1881, personally appeared Moses G. Farmer, and made solemn oath that the foregoing affidavit, by him subscribed, is true.

Before me,
J. HENRY TAYLOR,
Notary Public.

AFFIDAVIT OF HENRY C. BUCK.

HENRY C. BUCK, of lawful age, being duly sworn, says,—

My name is Henry C. Buck; age thirty; reside in West Somerville, Mass.; I have been associated with Prof. A. E. Dolbear (except a few months in 1876–7) since 1875 in studying and experimenting concerning the laws of electricity, sound and magnetism. For the last four years my special attention has been given to the construction of and experimenting with electric speaking telephones.

The permanent magnet telephone, the electrophone, the rotaphone, several varieties of telephonic transmitters, and the new Dolbear system were placed in my hands by Prof. Dolbear to develop, and they have, each in turn, received my undivided attention.

All telephones actuated by currents necessarily require to be sensitive to very feeble currents, because, unless the receiver respond to slight variations in the strength of the current, it cannot reproduce the more minute air-vibrations of speech.

Hence any currents, even if very weak, traversing them, other than those needed for the transmission of speech, are mischievous in their effects.

A theoretically perfect telephone must exclude all electrical conditions, except those which are to do the required work in the transmission of speech.

Long before the invention of the telephone it was well known that at times accidental currents of electricity were found upon telegraph lines with sufficient strength to work ordinary Morse instruments, and they had even been employed for that purpose. Moreover, these accidental currents occasionally became so strong, and likewise so variable, as to absolutely prevent the use of lines for telegraphic purposes.

It was not known, however, that such currents are continually present on all such lines; differing from the desired currents only in strength.

Since the invention of the telephone, it has been discovered that whenever the two ends of a conducting wire are grounded at some distance apart, currents of electricity will traverse the wire with a strength and direction determined by the continually varying electric potential of the two localities. These differences in potential arise from natural causes, as do other electric disturbances, such as thunderstorms and Aurora Borealis, and they are always present in some degree, and often sufficiently to seriously impair and not infrequently to destroy the efficiency of the magneto-telephone. When one terminus of such a wire is grounded near the place where another wire is grounded, and this other wire is employed in electric transmission, as a telegraph wire, the electric potential at such terminal will charge the ground for many rods. These electrical charges will give rise to currents of electricity in the first-mentioned wire.

Hence, for instance, if Morse signals are being sent from Boston to New York, thereby greatly varying the potential of the ground in Boston and vicinity, any wire with one of its ends grounded anywhere in Boston and the other grounded at a distant place, as at Salem or Lowell, will have similar currents set up in it, and a telephone included in such circuit will enable one to hear the signals that are being sent to New York. If this line be used for telephonic purposes, these Morse signals will act as an interference to the proper transmission of speech. It is owing chiefly to these two interfering agencies that the telephone has been hitherto restricted to relatively short distances. Again, the fact that a current of electricity in one circuit or conductor will give rise to a current in an adjacent parallel conductor, prevents, in a great measure, the use of ordinary telephones on lines adjacent to telegraph lines.

These difficulties in telephony must be overcome in one of the three following ways: —

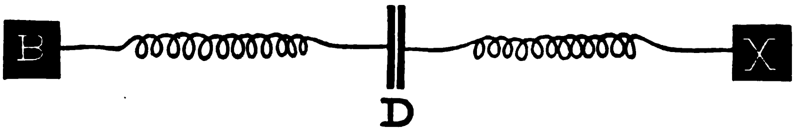
(1) By neutralizing in some way these deleterious currents. To accomplish this, many ingenious methods have been proposed, but with only partial success.

(2) By excluding such currents from the line, which can only be done by breaking the circuit.

(3) By making a telephone which is not affected by them.

The new Dolbear telephone meets the last two requirements; for (1) the circuit is broken within the receiving instrument by the practically infinite resistance of a film of air, and consequently these deleterious currents are excluded; (2) it is operated not by currents of electricity at all, but by high charges of static electricity.

The importance of breaking the circuit will be clear from the following diagram, where B represents Boston and X some point far enough away to be wholly unaffected by the currents from wires grounded in Boston.



Suppose the difference of potential between B and X to be sufficient to give a current through a continuous conductor grounded at B and at X of a certain strength. Now, suppose the conductor to be cut at D, and one of the Dolbear receivers to be put in the line. Then there can be no current from B to X, unless the difference in potential between these points be so great as to cause a disruptive discharge between the plates at D, which is very many times more than it ever is in fact. The Dolbear telephone D will be materially benefited by reason of the difference of potential between B and X, because that difference will keep both plates constantly charged, and therefore in better condition for doing their work. The only disturbing influence will arise from changes of the potential at B or at X. If both rise or both fall equally, it will not affect the Dolbear telephone at all. If there be any change of their relative electric tension, there will be a slight effect, but no practical effect, because any change of electric potential of the plates, generated by any fluctuations of potential at B or at X which can occur in practice, will be too slight to have any practical effect upon the Dolbear receiver. Now, if a magneto-receiver be used instead, there will be a current between B and X, the strength of which will vary as the potential at B varies from that at X, and the current will tend constantly to rapidly equalize the two; but as the causes which created the difference of potential between B and X do not cease to operate, and operate irregularly, there will be a continuous but very irregular current passing through the magneto-receiver, which will seriously affect, and may wholly prevent, its proper operation.

Experiments with the Dolbear telephone on actual lines varying in length up to over two hundred miles, made from time to time, have corroborated the expectations which the above conditions justify. When tested on such lines, even under very unfavorable conditions, it was found to be not subject to the difficulties I have mentioned. For instance, in England, between London and Norwich,—one hundred and twenty-five miles,—experiments were made under my personal direction, to test its capabilities. No effects were perceived from extraneous currents, and the receiving telephone gave no sound except the words of the speaker, which were plainly heard.

These experiments were performed during business hours, with an ordinary telegraph wire, exposed to very great induction from many other telegraph wires, and upon which similar attempts with various magneto-telephones had often been made, but never, as I was told, with any success.

I have recently tested the Dolbear system on a line 256 miles long, from Boston to New York, I being in New York, and Prof.

Dolbear in Boston; and found that there was a marked difference between the potentials of Boston and New York, caused mainly, as I believe, by the grounding of many more wires in New York than in Boston. The wire used was one of the American Rapid Telegraph Company's wires, and there were two cables forming part of it. Conversation was readily carried on, and extraneous currents did not impair the efficiency of the instruments. The magneto-telephone was also tried on this occasion, but the effect of the extraneous currents was far more than enough to drown all vocal sounds which could be sent by the transmitter.

I produce two receivers, marked "Exhibits Receiver 1," and "Receiver 2." The resistance of the secondary coil used with them should be about 3000 ohms. The battery used in the primary circuit should be a constant cell of low resistance. It is immaterial whether both plates of the receiver, or only one of them, be connected with the secondary coil; provided the plate not connected be charged or electrified in some way. In receiver 2 only one plate is connected with the secondary coil, and the other plate is electrified by induction from the plate which is connected, and this induction is given full effect by connecting the plate not in connection with the secondary coil to the metal band on the handle of the receiver; for this metal band being in contact with the hand of the listener, the body of the listener acts as a reservoir, so that the moment the terminal plate of the induction coil is electrified, the electricity of the plate not connected with the coil is distributed, the positive electricity of the plate being repelled if the charge be negative in the terminal plate of the coil, and *vice versa*.

In the diagram marked fig. 6, referred to in the affidavit of Edward Davis, the plate not connected with the secondary coil is grounded, but there is no current from ground to ground, and Mr. Davis is wholly in error if he means to say in substance that any current passes through the receiver. When the plate connected with one end of the coil is charged, say positively, the opposed plate connected to earth receives a negative charge. If the spot where this plate is grounded happen to be charged, the plate will be correspondingly charged, as I have before explained.

In using the receiver No. 1 it is difficult, if not impossible, to notice any difference whether both plates or only one be connected with the coil, provided the finger be placed on the post in connection with that plate not connected with the coil. If one of the plates of this receiver — it is immaterial which — be disconnected from the coil without putting the finger on its post, the receiver will still give out distinct and clear speech, but not so loud as if the finger be placed on its post, or the disconnected plate be artificially charged.

Mr. Davis is mistaken in several respects in his description of the transmitter. I do not know which one he saw, as many, each differing slightly from the others, have been used on the line connecting the office of Mr. Holmes and the rooms of Prof. Dolbear. But I have no recollection of any with the lead weight described by him, or with the pivots between two uprights, shown in figs. 2 and 3 of his affidavit. It is possible a weight may have been tried without my knowledge; but I feel very sure that it never was tried at all, and am certain that it was never used for any length of time. I never have seen any transmitter with the lead weight or with the pivots between two uprights, and I have no doubt that I should have seen them if they had ever been used. A great many experiments have been tried with this line, for it was constructed solely for that purpose, and although it is possible that the effect of a weight, as shown in fig. 2 of Davis' affidavit, may have been tried by attaching such a weight temporarily, I never heard of it, and I see no necessity for it.

H. C. BUCK.

UNITED STATES OF AMERICA,

DISTRICT OF MASSACHUSETTS, } ss.
COUNTY OF SUFFOLK, }

Subscribed and sworn to at Boston in said district this ninth day of January, A. D. 1881.

Before me,

[SEAL] J. HENRY TAYLOR,
Notary Public.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR ET AL.

COMPLAINANTS' AFFIDAVITS IN REPLY.

BOSTON:
ALFRED MUDGE & SON, LAW PRINTERS, 34 SCHOOL STREET.
1882.

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Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

American Bell Telephone Company
v.
Amos E. Dolbear et al.

AFFIDAVITS IN REPLY ON MOTION FOR PRELIMINARY INJUNCTION.

AFFIDAVIT OF CHARLES R. CROSS.

In my previous affidavit, I stated that electrical undulations, similar in form to the sound waves, were produced in the Dolbear apparatus by the sound waves themselves at the sending end, and were the cause of the sound waves heard at the receiving end. I do not understand that this is denied by the defendants' affidavits.

I find therein, however, some statements relating to the electrical phenomena which, it is said, there take place, coupled with the assertion that, in the opinion of the defendants' witnesses, these alleged phenomena are not in certain respects the same as those which they find in what they call the "Bell system." I do not find in those affidavits any attempt to define what they mean by the "Bell system," by reference to the fifth claim of Mr. Bell's patent 174,465, except on p. 16, of Mr. Pope's affidavit.

In my opinion, the conclusion that they are not substantially the same could not be drawn from the facts which those affidavits assert. I am quite sure, moreover, that the defendants' witnesses are in error in the assertions of fact on which they base their conclusions, as I understand them from the affidavits.

Mr. Pope says (p. 21): —

" The apparatus of Dolbear consists of an inducing magnet at the transmitting station surrounded by a coil of wire which is continuous with the linear conductor. The core of this magnet is provided with an auxiliary coil, a local battery producing a constant voltaic current, a varying resistance and a diaphragm or other body to respond to the movement of the air particles, which diaphragm, through the intermediate action of the parts just mentioned, acts to vary the degree of magnetic energy in the inducing core. Thus far the apparatus of Dolbear is substantially the same as the apparatus which is employed in the telephones in general use."

This statement is correct because the elements there mentioned, to wit, the vibrating diaphragm, the varying resistance, the battery, the primary circuit, the core of the induction coil, — that is, the whole apparatus at the sending station, — and the "linear conductor," "continuous" with the secondary coil, or, as it is more commonly termed, the line wire, leading from the transmitter to the receiver, are the same in both. The part of the apparatus where Mr. Pope finds a difference, I understand to be indicated in the following words, on p. 21, which follow the passage already quoted: —

" The apparatus at the receiving station, however, is radically different from that of Bell in its construction, principle and mode of operation."

This statement must be limited to the receiving instrument itself; for I have found that in fact if the Bell magneto receiver be inserted anywhere in any conductor employed by Mr. Dolbear in any arrangement of his apparatus, it will operate in the same way and with practically the same result as in that arrangement of conductors which has been more commonly used, and which the defendants refer to as the "Bell system"; this use of the Bell magneto receiver does not interfere with the simultaneous use of the Dolbear receiver.

Turning now to the electrical phenomena, I find these statements: —

Prof. Trowbridge says (p. 27): —

"In both the method of Bell and that of Dolbear, electrical variations corresponding in form with the air vibrations produced by the utterance of speech are set up *in the line wire*. Unless this is done, it is physically impossible that speech should be transmitted by electricity."

Mr. Pope says (p. 19): —

> "The method of transmitting vocal or other sounds over a telegraph line resembles that described in the patent of Bell in so far as the process of producing variations in the magnetic condition of the iron core of the inducing magnet at the transmitting station is concerned. That is to say, these variations of magnetic energy are controlled by *and are correlative with* the vibrations of the air particles which are taken up by the diaphragm or other body."

So far Mr. Pope is correct. He proceeds: —

> "But here the resemblance ends. The process of transferring this action by means of electricity to the receiving station, and of causing at that point the vibration of a resonant plate whereby the sounds are reproduced, is radically different."

Mr. Pope puts the last statement conjunctively. It should be divided. The process of transferring the action from the sending station to the receiving station is substantially the same in both; it is due in both to the disposition of electricity to flow from a point of higher potential to one of lower potential; it is possible in both only where the line wire is an electrical conductor; it is caused in both by varying the potential at the transmitting end; and the success of the apparatus is due to the fact that any special character given to the variations of potential at the transmitting end will thereby be impressed upon the electrical changes of all parts in electrical connection or relation with it. The difference in the process of vibrating the plate I will consider presently.

Mr. Pope says (p. 25): —

> "My attention has been called to the statement in Prof. Cross's affidavit, that both the instruments (Bell's and Dolbear's) form parts of an apparatus which, as a whole, transmits speech by means of certain peculiar variations of electrical currents." If this means that Dolbear uses a complete electrical circuit as part of his transmitter, in which circuit, for the purpose of inducing magnetic changes in the transmitting core, such variations of an electrical current are employed as Bell employs in the circuit in which his receiving core is placed, the statement is correct."

Mr. Pope is right in this, though he does not exhaust the whole meaning of my statement, which was intended to apply both to the local conductor and the line conductor, though the latter does not form a ring conductor. It is true, moreover, that the currents in this primary circuit are "similar in form to the sound waves" ; that, unless they were, speech would not be transmitted by the apparatus; and that the special form of electrical variations in this part is the caues of the special form of electrical variations, whether currents or not, in the line wire and in the receiver. Prof. Trowbridge expressly states this.

Mr. Pope's remark which refers to the above passage of his affidavit, "But I do not understand that any similarity of method in the two cases results from it," seems to me therefore to be erroneous.

Mr. Dolbear in his affidavit says: —

Page 6. "It is true that by Mr. Bell's method air waves produced in speaking are caused to vibrate the instrument which holds the electric cricuit under its control constantly, so that whatever movement of the diaphragm at any instant may be made will be converted into a corresponding electrical variation on the line wire. And I do the same."

Page 7. "It is a truism that the electric vibrations must conform to the air vibrations which produce them, if the electric vibrations are to be used to produce air vibrations like the first."

If he means by the word "truism" that the correctness of the method announced in Mr. Bell's fifth claim has been recognized ever since he announced it, I agree with him; if he means that it was known before, I do not agree with him; but I do not understand him to assert that it was known or had been practised before Mr. Bell's patent.

It is thus apparent from the statements in the defendants' affidavits that there is no essential difference in the apparatus except in that portion which consists of the receiver; and that in the operation of the apparatus as a whole, and in the electrical phenomena which cause or accompany the transmission of speech, there can be no essential difference, unless it be such as is due to or compelled by the difference in the receivers. The facts which are common to both, in construction and in operation, are essential to the one result which both produce, and did not exist in the operation of any apparatus anterior to Mr. Bell's patent. I am, therefore, of the opinion that, without reference to other similarities or dissimilarities, the fifth claim of Mr. Bell's patent 174,465 is infringed by the use of the Dolbear apparatus. The employment of electrical variations or "electrical undulations, similar in form to the sound waves" to which those variations were due, originated with Mr. Bell, was first directed by him, enabled him for the first time to transmit speech, and is precisely that which is claimed as novel in the fifth claim; the Dolbear apparatus transmits speech by employing them and causes them by the action of the voice on the transmitter.

The defendants' affidavits also enumerate the differences of construction which they conceive to be important so far as apparatus is concerned. They are confined, as has already been seen, to the receiving part. Each has a device by which "electrical variations, corresponding in form with the air vibrations produced by the utterance of speech, are thereby set up in the line wire" (to use the expression of Prof. Trowbridge), and are converted into corresponding sound vibrations at the receiving station. Both of them do this by employing these "electrical variations" to impart to an elastic plate at the receiving end corresponding vibratory motions. Both of them do this by exposing that plate to an attraction which is varied by and therefore in accordance with those "electrical variations." It is essential for both that this should be so. The difference is, that in the Bell magneto receiver the "electrical variations" pass around the core of a magnet, the attraction between which and the plate is thus and thereby correspondingly varied, and in the Dolbear condenser receiver the "electrical variations" pass into a plate of metal which is thereby correspondingly charged, and the attraction between which and an adjacent piece of metal is thus and thereby correspondingly varied.s

This is substantially what is stated in Mr. Pope's affidavit at the top of p. 20 and the bottom of p. 21.

Considering the phenomena which take place in the operation of the receiver, I find that the only difference which is stated is that in one case the electrical variations of special form which are caused at the receiving station by the operation of the transmitter and the electrical conductivity of the line wire serve to vary the attractive power between the core of an electro-magnet and a plate, and in the other these "electrical variations" are caused to vary the attractive power between a mass of metal and a plate. In both cases, however, the fact is, and it is essential, that the variations in attraction (and consequent motion) do and must correspond to the "electrical variations" which cause them.

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Undoubtedly, electricity possesses two well-known powers or capacities or properties, by virtue of which it has long been used to produce attraction; one is, that by virtue of which it causes an iron bar around which it passes to attract such an iron plate, and another is that by virtue of which a body electrified by it "will attract other bodies except such as are electrified by like electricity." One of the receivers utilizes one of these properties as a means of converting electrical variations into corresponding sound waves, and the other utilizes the other as a means for the same purpose.

Mr. Farmer says, referring to what he calls the "Bell system" and the "Dolbear system" (p. 29): "But the kind of electricity or, *more properly speaking*, *the property of electricity*, *employed* is different, the work done by it is different, and the apparatus by which it is done is different."

I read this as a statement that, "properly speaking," both employ the same kind of electricity but utilize different properties of it. The work done, however, is not different; in both, it consists in producing similar sonorous vibrations of an elastic plate. I understand also that Mr. Farmer's statement is confined to the receiver alone; for the other witnesses for the defendants state that all other parts of the apparatus are substantially the same. Moreover, many properties of electricity are employed: as those which concern its generation, the mode of varying it at the transmitting station, and the property by which variations caused at one end of a conductor are propagated to the other without material change. These properties are employed by both as necessary to the operation of the apparatus of each.

All these properties and the manner of using them being the same in both, the difference consists in this, that when by virtue of these properties and the particular construction and operation of the transmitter and line wire (being the same in both), the electricity reaches the receiving end in precisely those measured variations of quantity which Mr. Bell was the first to produce and which are essential for speech, the one person utilizes one long-known property of electricity to make these variations perceptible to the ear, and the other uses another long-known property.

This is correct, but it is not all; I add to this the fact that it was known before Mr. Bell's time that both these properties might be used as a means of making electrical variations sensible as sound vibrations.

I do not mean to say that, before Mr. Bell's time, condenser receivers had been used for articulate speech, because I believe that no man had transmitted articulate speech electrically before Mr. Bell; I mean that before his time such receivers were used to convert into sound waves such electrical variations as had been produced, and that such condensers as were then used for that purpose will practically act as receivers of articulate speech when substituted, with their adjuncts, for the Bell magneto receiver in well-known forms of the Bell apparatus. Mr. Dolbear's variation in construction from those old condenser receivers may have improved their operation, but has not essentially changed its character.

The defendants, if I understand their affidavits, assert another difference to be, that Mr. Bell produces currents, and that Mr. Dolbear does not produce currents, but merely variations of electric potential, and that this is important. Mr. Pope says (p. 25), in reference to the respective transmitters, that they "are corresponding elements in their respective systems of apparatus. As already mentioned, either of these elments may be used in the Bell system to produce undulatory currents, and when so used they are the substantial equivalents of each other; but Dolbear does not use either of them to produce an undulatory current [*Mr Pope is here speaking of currents in the line wire alone*], he uses the transmitting circuit to produce a variation of electrical potential."

Mr. Dolbear says (p. 9): —

> "The electric variations utilized in my method are radically different from those used in Bell's method. In Bell's method variations in current strength are essential, while in my method the electric variations are static." Referring to the phenomena which take place in the induction coil, he says, "The secondary coil will become electrified, one end being positive, the other negative, — that is, the ends will be at different potentials, — and their potentials will vary instantaneously at each and every variation of the current strength in the primary coil, and there will be no current, but simply electric tension or electric pressure in the secondary coil."

This is an imperfect statement of what takes place. In the secondary coil itself a current is compelled or forced into existence by each variation in the magnetic condition of the core. This current, which is in a large coil, very strong though very transient, heaps up, if I may use this expression, towards one end of the coil all the positive electricity which the wire possesses, and towards the other end all its negative electricity; and it is this current which causes the difference of potential, or, as Mr. Dolbear calls it, the electric tension or electric pressure at the two ends. This is the generally accepted statement of the operation.

Mr. Fleeming Jenkin, in *Electricity and Magnetism*, speaking of electrical induction from magnetic variation, says (p. 76): —

"In the broken circuit, on the contrary the current is not produced by a difference of potential between different parts, but the electromotive force drives positive electricity to one end of the wire and negative electricity to the other, producing a difference of potentials which will send back a reverse current as soon as the inducing action of the magnet is over."

Thus the potentials at the terminals of the coil are the result of a current. The potential of either end, when brought to bear on a conductor subject to no other electric force, will in turn produce a corresponding current. That both of these are true currents is shown by the fact that a magneto receiver will be affected and will speak if its coil is looped into the central portion of the secondary helix, and will also speak if its coil forms part of a conductor between either terminal and a neutral body or any body of different potential.

If it were true (as it is not) that there were no currents in the Dolbear apparatus, it would not constitute a departure from what is set forth in Mr. Bell's fifth claim. That claim refers to "electrical undulations similar in form to sound waves." I do not find that the language of the claim limits it to variations in currents, and excludes variations in potential, in cases where the voice of the speaker compels both to follow the same law of variation, and thereby produce the same ultimate result. But in truth Mr. Dolbear cannot obtain variation of potential in his apparatus without obtaining corresponding currents. He does, in fact, obtain currents both in the local circuit, and in the line wire; in both they are not merely incidental, but essential to the transmission of speech by his apparatus; and in his apparatus they are similar in form to the sound waves.

I will state the electrical phenomena which take place in the use of the speaking telephone apparatus arranged as usually employed by the plaintiffs and using the Bell magneto receiver. I understand from the affidavits (*e. g.*, Mr. Farmer, pp. 27 and 29; Mr. Pope, p. 21) that this is conceded to conform to the fifth claim of Mr. Bell's patent, 174,465. A diagram of it is given as Fig. 1, p. 21, *infra.*

The transmitter is provided with an elastic vibratory plate or disk.

The sonorous vibrations of the air produced by the vocal organs compel this plate to take up vibratory motions of that special form which is characteristic of the articulate sound produced.

Every movement of this plate causes in a battery circuit a corresponding variation of resistance, and consequently a corresponding variation of current.

This causes a corresponding variation of magnetism in the core of the induction coil.

This causes a corresponding transient current, of momentary duration only, to arise in the secondary helix, whereby the electricity of the secondary helix is compelled to flow towards one end of it, thus raising the potential at one end above its normal value and lowering it at the other below its normal value.

When two bodies of different potential are joined by an external electrical conductor, electricity is transferred or flows with great rapidity from the point of higher to the point of lower potential, until an electrical equilibrium is established.

With a given apparatus in which the distant body is subject to no electrical forces except those due to operations at the sending end, the flow depends upon the potential of the body at the sending end, upon the amount of electricity supplied, upon the time during which it is supplied, and upon the capacity of the receiving body to receive it; the electrical change at the distant end is the consequence of the flow and of nothing else.

Thus, control of the electrical condition at one end of a long, slender (and therefore cheap) conductor enables the operator to control the electrical condition of a far-distant end, not instantaneously, but with an interval which is so excessively short that it cannot be readily noticed under ordinary circumstances.

These two properties of electricity fit it for the rapid and cheap transmission of intelligence by appropriate signals.

When the electricity arrives at the receiving station, it there affects a special instrument provided with a vibratory plate in contact with the air and so constructed that every electrical change which reaches the instrument gives to its plate a motion which in turn imparts a corresponding motion to the surrounding air. It does this by attracting this plate more or less towards a neighboring body which is or will act substantially as if it were immovable. While the attraction is increasing, the plate moves in one direction; while decreasing, it moves in the other.

Each member of this system is found originally in a state of rest or equilibrium. The voice does work in disturbing these by the application of a disturbing force; to this (and its effects) are due the motions and changes which produce the desired result.

The transmission of speech by this apparatus offers therefore a problem in dynamics or kinetics and not in statics.

The spring or lever in a piece of mechanism, when at rest, will support a weight in equilibrium; the study of them in that condition is a branch of statics. Apply to them a force *ab extra* which causes them to move and to move the weight; the study of the operation of the mechanism in this condition of motion belongs to kinetics.

The electrical changes in telephonic transmission are continuous, not intermittent, — continuous, however, not in direction but in succession. The sonorous vibrations of the air do not consist in a motion of translation continually onward, but in a to-and-fro motion, very short, very rapid and without cessation. In the use of the magneto transmitter the currents are alternately to and fro; with the battery transmitter in direct circuit the current does not go on continually increasing, or continually decreasing, but alternately rises and falls; when the battery transmitter is used with an induction coil, the currents are alternately to and fro, as with the magneto transmitter.

This alternating change or motion is implied in the term "undulation" or wave motion.

Sir George B. Airy (on *Sound*, London, 1871) says, p. 22, that the "general conception of a wave" is that "the nature of the motion is such that the movement of every particle is limited while the law of relative movement of neighboring particles is transmitted to an unlimited distance either without change, or with change following a definite law."

"In all wave motions there is one general character; it is that a state of displacement travels on continually in one direction without limit, while the motion of each individual particle is, or may be, small and of an oscillating character. And this is the general conception of a wave."

Mr. Bell's invention did not lie simply in causing motion, but chiefly in the special character of the electrical changes which he directed; viz., that the electrical undulations shall be similar in form to the sound vibrations to which they are due. By this means he caused the special kind of sonorous vibrations at the receiving end which no one before his time had known how to produce.

The Dolbear apparatus consists of a transmitter, battery, primary circuit, core of induction coil and secondary helix thereof substantially the same in character as the ordinary form of the Bell. A diagram of it is given in Fig. 2, p. 21, *infra*.

All the phenomena which I have described take place in the Dolbear in the same way as in the more common Bell apparatus.

These phenomena in both are due to the same causes, and to the same properties of electricity.

One result in both cases is (considering now the case of a single charge) a rise of potential at the terminal 1.

This rise of potential determines a current towards any body of lower potential, to which it may be connected by a conducting wire.

If terminal 1 be joined by an electrical conductor to any body of lower potential, then electricity will flow from 1 along that conductor to the other body.

This flow is termed a current.

The point 1 may be so joined to a body A, in which case the flow will be towards A until it is "filled up."

If it be joined to the terminal 2, the flow will be towards 2. But it will be a flow or current in both cases.

In both cases it will be the difference of potential which will cause it and every variation of potential or electrical condition of the body at the transmitting end and will cause and will therefore control the flow or current and its effects at the receiving end.

In both cases the control of the transmitting end will for that reason control the changes at the receiving end.

All that is true of the Dolbear conductor and apparatus as of the Bell; and it is because it is true that the Dolbear apparatus can transmit signals the character of which can be determined by the operator at the transmitting end.

Mr. Bell's method is defined in the fifth claim of his patent 174,465. Electrical signals generally are given by electrical variations. In this claim, Mr. Bell pointed out as the distinctive feature of his method that the electrical variations in their successive changes should conform to the law which expresses the vibrations of a particle of air engaged in producing the sound to be transmitted; the apparatus was to be one in which the action of the voice should produce this special type of electrical undulations. He was the first who had pointed out this method (or any method) competent to transmit speech by electricity. His novel result was due to this novelty of method. Mr. Dolbear's apparatus accomplishes this same result, because in action it conforms to and employs this novel method, which is stated in Mr. Bell's patent and claimed as his invention in his fifth claim.

A device at the receiving end which will there convert into sound waves the specially formed electrical undulations which have reached it is an essential portion of the apparatus. Mr. Bell employed what is called a magneto receiver; Mr. Dolbear employs what is called a condenser receiver. It is true that the two are not identical as independent devices. But this does not change the method employed nor the essential character of the apparatus as a whole. For in each apparatus the transmitter is the same, and performs the same function, to wit, produces the same character of electrical variations; the line wire is the same and performs the same function; the one receiver is used in place of the other because it can transform the electrical variations into sonorous vibrations of corresponding character.

As I understand the affidavits filed by the defendants some of them assert that Mr. Bell uses "currents of electricity" and that Mr. Dolbear does not.

I have already stated that there is nothing in the language of Mr. Bell's patent, nor in the nature of that part of the novelty introduced by him which is essential to the novel result, that excludes from his claim electrical undulations which are not "currents," if such there be. But in fact currents are present in the local circuit and in the line in the Bell and in the Dolbear wire; in the apparatus of both they are essential to any operation of the instrument; neither will transmit speech unless the current variations are similar in form to the sound waves; in both the essential function of the transmitter is to produce this particular form of current by the action of the voice. It is only when these special articulating currents have reached the receiver that any difference begins, which is material to the operation *of any part* of the apparatus.

The current which I refer to in the line wire is that flow of electricity which the transmitter causes to or from the receiver.

When the terminal of the induction coil is connected by the line wire with the receiving end of the line and the potential of the terminal is suddenly raised, electricity flows along the conductor until so much has flowed that the whole conductor, including the distant end, has been raised to the same potential, if the flow is allowed to continue so long.

If the conductor to be filled, either the line wire or the metal plate or other body at the distant end, is of large capacity to receive and hold electricity, as compared with the ability of the line wire to convey it, and if the supply of electricity furnished for transfer is large, a considerable time will be required for the transfer, and the current will be of long duration.

Thus if all the electricity which the earth is capable of holding had to be transferred over an ordinary telegraph wire to a reservoir formed of another planet, with any ordinary difference of potential, a very considerable time would be required.

If either reservoir were of small size the flow would continue a short time and would be what is called a transient current.

If by artificial means (as by a voltaic battery) a continued supply of electricity were furnished at one end, and all received at the other were drawn off, the current would go on until the apparatus wore out. This would be called a permanent current.

But whenever a point at one potential is connected with a point at another by an electrical conductor a true "current" or flow of greater or less duration necessarily takes place.

It is only by means of such a flow that the electrical condition of one end controls that of the other. In the Dolbear apparatus the plate moves towards the body of the instrument on a rise of its electric potential. This is due to a forced rise of potential at the transmitter, which sends a flow of electricity along the line conductor, filling or charging the plate of the receiver and thereby raising it, potential.

Upon this topic I will quote from a writer who is distinguished for the extreme precision and accuracy of his statements as well as for his knowledge of electricity. I refer to Mr. Fleeming Jenkins work on *Electricity and Magnetism* first published in 1873. My references are to the pages of the edition of 1876.

Page 26: "Difference of potential is that difference of electrical condition which determines the direction of the transfer of electricity from one point to another; but electricity cannot be so transferred without doing work or requiring work to be done, hence the following definition: Difference of potentials is a difference of electrical condition, in virtue of which work is done by positive electricity in moving from the point at a higher potential to that at a lower potential; and it is measured by the amount done by the unit quantity of position electricity when thus transferred."

Page 39: "If two electrified conductors A and B, which are at the same potential, be joined by a wire, no disturbance in the electric distribution in the system will take place, unless indeed the wire be of sensible size relatively to the other conductors, and at a different potential; but, assuming the wire to be small, or at the same potential as A and B, the electricity on the bodies after being joined will be in equilibrium as before, the necessary condition of equality of potential throughout being satisfied. If, on the other hand, A be at a higher potential than B, positive electricity must, when the connection is made, flow from A to B, to re-establish electric equilibrium. The amount of the electricity thus transferred must be such as will restore the equilibrium. It will be great when the difference of potential is great and when the size of the bodies is large, and small under the opposite conditions. The existence or continuance of the flow of electricity from one point to another depends solely on the difference of potential between the points. The magnitude of the conductors has only one influence in the result, by requiring that a larger quantity of electricity shall flow to re-establish equilibrium."

Page 52: "*Current.* Electricity has already been frequently spoken of as redistributing itself over a given conductor, or moving from one conductor to another along a wire; and we may with propriety speak of the current of electricity by which the redistribution is effected." . . . "By using two large conductors A and B, or two Leyden jars of large capacity, and electrifying them with a frictional electrical machine of considerable size to a high potential, a considerable quantity of electricity may be accumulated on A and B, and a considerable current will flow from A to B when they are joined."

Page 80: "Any change in the distribution of the statical charge of electricity on the surface of bodies produces currents until the redistribution is completed and equilibrum is restored. We find no difference of kind between these currents; they all have the same properties but combined in very varying degrees."

Page 74: "The conductor in which the current is induced need not form what is called a closed circuit, *i. e.*, such a conductor as is formed by a ring of wire round which the current can continue to flow permanently if a permanent electro-motive force be kept round it, as distinguished from a broken circuit, such as would be formed by a ring of wire incomplete at one or more points, where the presence of air or other non-conductors would stop any permanent current; but although the induced current will be very different in the two cases of a closed and open circuit, it will be produced in both. In the closed circuit we may have a current induced without difference of potentials between the parts. We cannot have difference of potential between two parts of a conductor without a current ensuing; but we may have a current due to electro-motive force, without any difference of potential."

Page 78: "When the poles of the galvanic cell Z C are first joined at N and M to the wires A, B, C, D, electricity will rush from the cell into the wires. This electricity has to charge each portion of the wires statically. The current begins close to the cell some time before it reaches the remoter portions of the wire. It flows at different rates through different sections of the wire according to their size, capacity and material."

Page 79: "If the cell be connected with two long wires insulated at the further ends (as in Fig. 51), or if one pole be connected with the earth and the other with a large, insulated conductor or long wire, we shall have a series of precisely similar phenomena, except that the final condition of equilibrium will be that in which all parts of the conductors being duly charged to the potentials which the cell produces, no further current will flow at all."

J. Clerk Maxwell, *Electricity and Magnetism*, vol. i, p. 289: "In the case of the current between two insulated conductors at different potentials, the operation is soon brought to an end by the equalization of the potentials of the two bodies; and the current is, therefore, essentially a transient current."

Culley, *Handbook of Practical Telegraphy*, London, 7th ed. 1878, speaking of the discharge of the rubber of a frictional machine through a fine wire, says, p. 7:—

"Before the discharge takes place or the current commences to flow, the electricity is said to be in the static condition; *during the discharge, it is in the dynamic condition, because it there exercises force or performs work.*" "Whenever there exists a difference of potential between two points connected by a conductor, a current passes between them until equilibrium is established."

Preece & Sivewright, on *Telegraphy*, p. 5: "Potential implies that function of electricity which determines its motion from one point to another."

Deschanels' *Natural Philosophy*, by Everett, New York, 1878, p. 558: "A conductor is said to be in electrical equilibrum when there is no electrical force in any part of it; in other words when it is completely free from currents of electricity." P. 559, "When a conductor is not in electrical equilibrum, currents set in tending to restore equilibrum; and the direction of such currents is always from places of higher to places of lower potential."

I have multipled these quotations, not because I suppose there is any doubt about the fact, but in order to show that the transient flow of electricity between two bodies of limited size at different potentials is commonly spoken of as a current.

I will now refer to the facts which show that it possesses those properties of a current which we have to deal with in the telephone, and which affect the magnet of the magneto receiver.

One method of determining the electro-motive force of a battery (ordinarily looked upon as the furnisher of a "current") is to measure the potential of a condenser or other body to which one pole is connected; when the body is thus charged, its potential, in the case of a plate, is measured by the attraction exercised between it and a body either neutral or negatively charged. Convenient statements of this are found in Fleeming Jenkin's work, Chap. V. and Chap. XIV., and p. 267, and in Sir William Thomson's *Electrostatics and Magnetism*, p. 281.

The capacity of a condenser or other body, or the amount of electricity which it can contain, is commonly measured by allowing it to discharge itself through a circuit which includes a galvanometer. See Jenkin, p. 162.

The condenser shunt, a well-known device, depends in part upon the fact that the transient current due to the inflow or outflow to and from an electrical reservoir of moderate capacity (a condenser) acts upon magnets as other currents do, or combines with other currents in acting on magnets.

One of the recognized and usual modes of ascertaining the position of a break in a telegraph line is to consider the line from the testing office to the break as an empty reservoir, to fill it up with electricity, measure the inflow by a galvanometer and thus calculate the length of wire from the amount of current required to fill it; or, conversely, to fill that part of the wire and measure the current while discharging. These currents are transient, but they are "currents." Of this usual test Schwendler, *Testing Instructions*, London, 1879, vol. i. p. 136, says: —

"The capacity of a line is proportional to the quantity of its charge with a given electro-motive force, which can be found either by measuring the transient current due to 'charge,' or by measuring the transient current due to 'discharge.'"

These measurements are made by means of the galvanometer, which is an instrument consisting of a magnet acted upon by the current. "A galvanometer is an instrument intended to detect the presence of a current and measure its magnitude." Jenkin, p. 187.

The speaking telephone never employs permanent currents in the sense in which that term is generally used, whether the transmitter be of the magneto type shown in Mr. Bell's second patent 186,787, or of the type referred to in the affidavit of Mr. Davis and in the affidavits of the defendants as a battery transmitter furnished with an induction coil (as shown in Fig. 1, p. 21, *infra*). A succession of transient currents follows each other in the wire. The transmitter first raises the potential of that end of the line which is at the sending station, and then lowers it; in one case, it determines a current towards the distant end, and in the other case from it. Every time the potential of the sending end rises above that which the distant part possesses (whether it be the normal condition of the latter or that given to it by the last preceding electrical impulse), at the same moment a current is caused from the sending end; each time its potential is forced below that of the distant end electricity flows back again. Thus a succession of currents takes place, each transient considered by itself, but each succeeded by the next without intermission, so that the electrical changes are as continuous as the waves of a continued sound. Each current, considered by itself, lasts much less than one thousandth of a second.

This is equally true of the Dolbear apparatus: transient currents are present; the duration of each and the form of each (so far as the tranimission of speech is concerned) are the same in both.

As already stated, when the circuit is in the form of a ring, that is, a wire closed in upon itself, a permanent current can flow in it; when the conductor joins two reservoirs the duration of a current depends upon the capacity of the reservoirs. Those used in the Dolbear apparatus are small and would not maintain a long-continued current. But a long-continued current on the line wire is not required nor commonly used in telephony.

The sending reservoir or source, which is the controlling portion, is the same in both. The receiving reservoir, though small, is large enough for the transient currents on which the operation of the Bell magneto receiver depends. Though small, as compared with the mass of the earth, it is filled and emptied so many times a second that its capacity is sufficient for this purpose.

It is certain that both the charge and the discharge of a condenser or other limited receptacle of electricity is due to, and accompanied by — I may say consists in — a practically applicable and useful flow or current of electricity through the connected wire. Some further examples of this will be given on pp. 28, 29, *infra*.

This is so well settled that, as already stated, a common way to measure the amount of electricity which a condenser holds, or is capable of holding, is to empty it or fill it through a conducting wire and measure the flow by an instrument called a galvanometer, which measures a current by its influence on a magnet.

The galvanometer is not adapted to detect or measure the articulating currents of any telephone apparatus: they are of excessively short duration; and, while they are of a nature to affect a galvanometer, yet the time during which they act is so brief and their reversals (either of direction or of change) are so quick that the galvanometer needle, as usually constructed, is too sluggish to respond to an extent readily perceptible.

The magneto telephone itself is of course sensitive to telephonic currents. I have employed it to ascertain their presence in the Dolbear apparatus with the more confidence, because Mr. Dolbear says, in effect, in his affidavit (p. 9), that variations in current strength are essential for the operation of Mr. Bell's magneto receiver. If I understand correctly, the meaning of the first part of page 10 of Mr. Dolbear's affidavit (of which I am not sure), he intends to say that a Bell magneto receiver inserted in the line conductor of the Dolbear apparatus will not there find the kind of energy required to work it; and this assumption appears to be an "emphatic basis" of his belief in a substantial difference between his apparatus and Mr. Bell's more ordinary form of apparatus.

I have tried the following experiments with the following results. I have performed each of them at least twice on different days.

Some of them I have repeated many times in order to assure myself that the results were not due to or affected by any accidental disturbing causes. In all of them which I here state, and in most of the others, the transmitter and receiver were placed in separate buildings; and I assured myself whether speech was transmitted or not by causing the assistant to repeat to me what he heard or what he said; and I frequently caused him when he listened to report his results without informing him of the various changes which were made. In every experiment here stated I also listened myself.

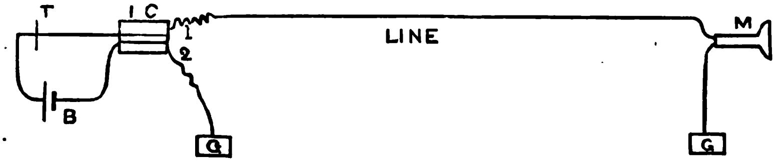

Fig. 1.

I will describe the diagrams I have made, and the instruments used. The transmitter T was a variable resistance battery transmitter with a battery B in a local circuit which included the primary of an induction coil (I C). The secondary helix of one coil used had a resistance of 4,000 ohms. I occasionally used a somewhat larger coil, belonging to the Institute of Technology, but found no material difference. G signifies ground which was obtained on gas or water pipes in the usual way. Fig. 1 shows the ordinary arrangement adopted by the Bell Company for the Bell system with the Blake or Edison battery transmitters. One terminal of the secondary helix is connected to the line and the other to earth. M signifies a magneto receiver, which was of the usual form. In the subsequent figures C signifies a condenser receiver. I used two Dolbear condenser receivers. The first was made at the factory of the plaintiffs and was intended to conform to those made by Mr. Dolbear. I am informed that it was shown to Mr. Dolbear and was declared by him to be properly made. After the defendants' affidavits were filed, I caused copies to be made of the two Dolbear receivers filed by Mr. Buck, and many of the experiments here reported were either originally performed or repeated with these. I did not find any material difference between these and those previously used.

In these experiments I also used instruments which I designate as the Wright condenser, the Ferguson condenser and the Varley condenser. These were made for the purpose of these experiments in conformity to the descriptions given by those three writers and appended to this affidavit. I also used another receiving condenser, which was made during the year 1880 for a speaking telephone receiver in accordance with the directions of Mr. George L. Anders. I saw this receiver during the year 1880, when some experiments were performed with it at the laboratory of the Institute.

The line wire was of the usual size; it was of copper office wire indoors and of the usual line wire size outdoors. The line was not constructed especially for these experiments.

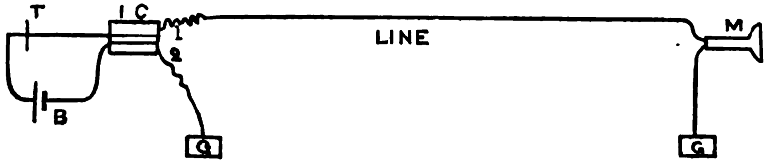

Fig. 1.

Fig. 1 represents the usual speaking telephone connections. With all the coils this gave excellent speech.

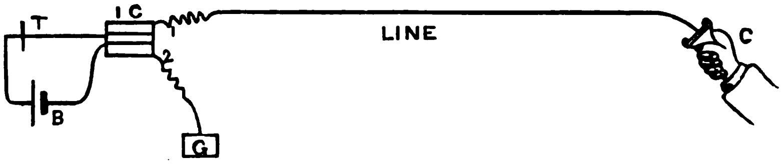

Fig. 2.

Fig. 2 shows what I understand to be the Dolbear arrangement of conductors in the most pronounced form. One terminal of the coil, marked 2, was left in the air, insulated as shown. The receiver was grasped so that the listener was in electrical connection with the back plate of the instrument, but insulated from the first front plate and line. This is the manner in which Mr. Dolbear intends that it should preferably be used. I could understand articulate speech through it. I then repeated the experiment by connecting the terminal 2 of the coil with the back plate of the Dolbear receiver, but found no change of result. I again repeated the experiment by grounding the terminal 2, and grounding the back plate of the condenser. I did not perceive any substantial difference in the result. I then removed the grounds and held the receiver so that I was not in electrical communication with the receiver at all. Speech was audible, but poor and faint, and hardly intelligible.

In the experiments which I here report, I left the terminal 2 of the coil in the air and insulated, except where I have expressely shown it grounded; and wherever the receiver, or the receiving end of the line, is shown as grasped by the hand, it was so grasped that the operator was in electrical communication with it. I also took the precaution, in all the experiments where the operator was in electrical communication with any part of the apparatus, of causing him to be insulated, by standing on a thick plate of vulcanite placed on a floor cloth of linoleum, though I did not find that such special insulation changed the result. The human body is of ample electrical capacity for any form of apparatus which I used.

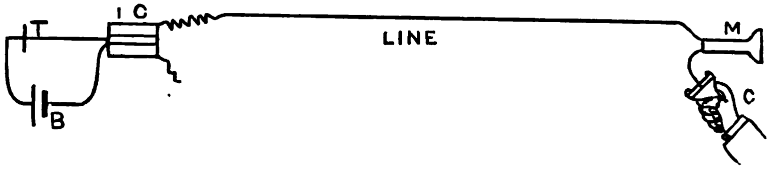

Fig. 3.

In the experiment Fig. 3, the conductors and connections were of the Dolbear character as in No. 2, but a Bell magneto was looped into the Dolbear conductor. There was, under the precautions already named, no ring circuit in the line, and no currents passed through the magneto receiver except such as were due to the capacity of the wire and the front plate of the Dolbear condenser receiver, assisted by the inductive effect of the back plate and connected masses. I heard articulate sentences at the Dolbear condenser and at the Bell magneto receiver, as well as in the arrangements Figs. 1 and Fig. 2 respectively. I have repeated this experiment many times on different days.

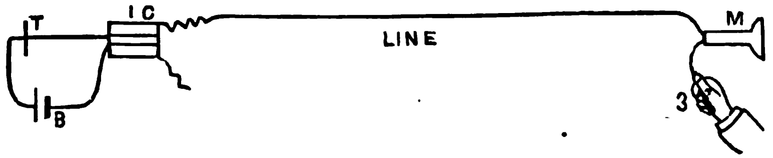

Fig. 4.

With this arrangement, Fig. 4, one terminal of the coil in the air and insulated and the person holding the receiving end of the wire insulated, the transmission was as good as in No. 1.

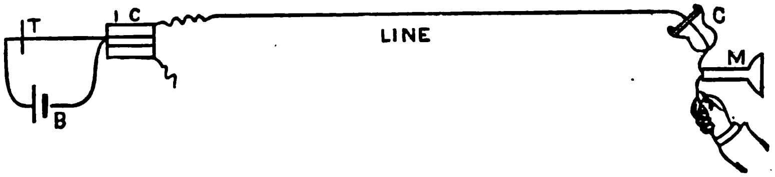

Fig. 5.

Fig. 5. With this arrangement speech was obtained both with the Dolbear condenser receiver and with the Bell magneto. The latter was about as good as in No. 1; the Dolbear acted, with regard to the magneto, like an ordinary condenser.

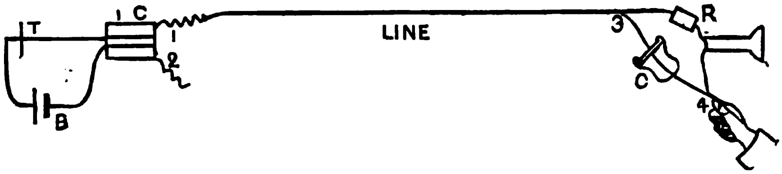

Fig. 6.

Fig. 6. In this I connected the front plate of the Dolbear condenser receiver to the line in the usual way and connected the insulated operator with the back plate by a wire. I passed a shunt or divided circuit around the receiver, and in this branch I placed a Bell magneto-telephone. The electricity passing along the line would come to the point of division 3, and a part of it would pass off through the shunt and the magneto telephone. I placed in this branch shunt an artificial resistance R, of about 80,000 ohms. This offered an

impediment to the too easy passage of the transient current, and therefore the shunt, with this resistance in it, did not much change the electrical condition of the rest of the apparatus from what it would have been if the shunt were not there, but at the same time allowed current enough to pass to work the Bell magneto. With this arrangement I heard speech well in both instruments. Upon removing the resistance R, the transient current of electricity flowed off so freely through the shunt that not sufficient difference of potential was produced between the two plates of the Dolbear to cause an audible effect. The same kind of operation went on in the Dolbear as before; but the action was so much diminished as not to be perceptible to the senses. As resistance was gradually introduced at R, the sound in the Dolbear became perceptible and gradually increased in loudness. The result is what one would naturally expect in the case of a flow of a transient current from the coil, and occurs because of the relations between resistance, potential and current.

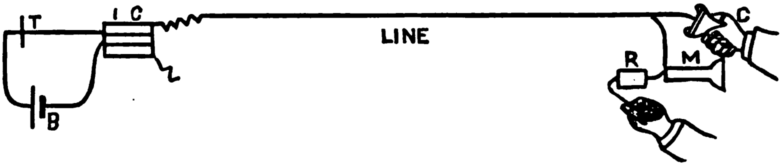

Fig. 7.

The experiment, Fig. 7, depends upon the same principle as Fig. 6. The two receivers were held by different persons insulated from each other. With a high resistance at R speech was heard in both receivers.

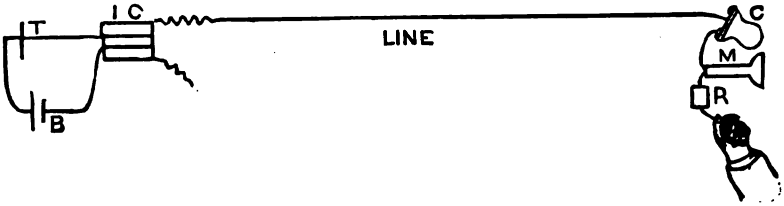

Fig. 8.

Fig. 8. In this experiment the electricity, starting from the coil, flowed to the front plate of the Dolbear receiver, then through th

plate out again, through the magneto receiver, then through a high resistance to the operator. The two receivers were held by different persons. That a current did actually flow through the plate of the Dolbear receiver is shown by the fact that what came out from it worked the magneto receiver while the resistance R kept the potential between it and the coil high enough to produce clearly audible effects in the Dolbear condenser receiver.

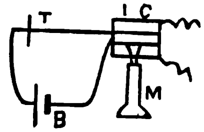

Fig. 9.

I have said in a former part of this affidavit that a current is produced in the secondary helix itself. In the experiment shown in Fig. 9, I used a large coil of about 4,000 ohms' resistance, with the two terminals in the air and insulated, so that there was no external conductor or circuit. In the middle of this coil, as near the exact middle as I could conveniently get at it, I looped in a magneto telephone. From this I got articulate speech perfectly.

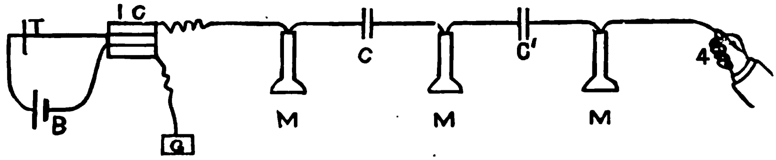

Fig. 10.

In this figure, which represents experiments I have tried, the line was broken by condensers. M represents the ordinary Bell magneto receiver. C represents condenser receivers. The arrangement is a bad one in so far as it entails considerable waste of force, but, using Bell magnetos and Dolbear condensers, all gave articulate speech.

I then placed a Wright condenser receiver at C′ and got speech in all; but it was hardly intelligible at the Wright C′. I expected this, because the electrical capacity of the Dolbear is very much less than that of the Wright, and therefore the former could not fill it. Then replacing the Dolbear at C by a condenser of ordinary capacity (50 sheets of tin-foil), I got intelligible speech readily out of the Wright at C′. In this case I had the farther end, 4, connected to earth instead of the hand; but I have found in repeated experiments with these instruments that the change is immaterial.

I then replaced the Wright by a Ferguson silvered paper condenser, and got good and intelligible sentences with it as a receiver.

The conclusion and the facts are, therefore, that the Dolbear apparatus transmits speech by causing "electrical undulations, similar in form to the sound waves," which constitute the sound to be transmitted. Currents exist in the Dolbear apparatus. In every part of every conductor contained in it, they exist to an extent which will practically work the Bell magneto receiver.

Quoad the transmission of speech, they exist both in the line wire and in the primary circuit as much as in more ordinary arrangements of telephone conductors. They are in both of a form similar to the sound waves; and it is essential that they should be. They are of this form in the primary conductor; and they must be there in order that they may have the same form on the line wire.

It is true that the currents employed in the more ordinary arrangement of telephone apparatus will not operate the Dolbear. This is not because they are currents, but because they are not of sufficiently high potential. The transmitting coil ordinarily used is much less expensive and powerful, and the grounded circuit allows the electricity to escape so rapidly that the potential never rises to the great strength required for an unsensitive instrument like the Dolbear.

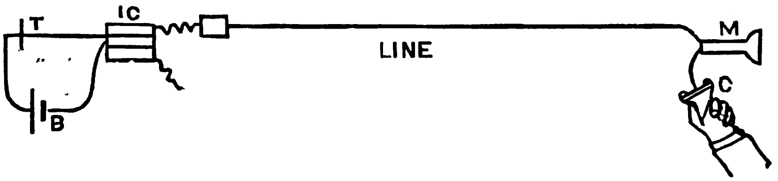

Fig. 11.

Mr. Dolbear says in his affidavit that Ohm's law applies to Mr. Bell's magnetic receiver, and does not apply to his condenser receiver. I understand this to be a statement that a high resistance impairs or prevents the working of one and not of the other. The effect of resistance on the high tension transient secondary currents in the telephone is not perfectly understood; but the following experiments show that the two instruments do not materially differ in these respects. In Fig. 9 I inserted 200,000 ohms, and this diminished somewhat both Bell and Dolbear, then put in over a million ohms of plumbago resistance; this prevented utterance in the Dolbear, though I got some faint sound in it. But I understood sentences in the Bell magneto receiver with the same conductor. The farther terminal of the Bell magneto was sometimes connected to earth, and sometimes held in the hand in this experiment, but I found no material differene. I then took out the induction coil end, which was of 4,000 ohms and substitued for it a more powerful coil of 6,260 ohms in the secondary. The increased electro-motive force of this caused enough electricity to pass the resistance in the limited time allowed in a speaking telephone to work the Dolbear receiver and produce effects which were audible and distinguishable.

That such a resistance does not absolutely prevent the passage or flow of a current of electricity is proved by the fact that it did not prevent the Bell magneto receiver from reproducing articulate speech. It would at all not prevent the transmission of "electric pressure," if such a thing exists, any more than the moderate size of a pipe would prevent the maintenance of a steady hydraulic pressure. But if the problem changes from one of statics to one of kinetics, and the operation of the instrument involves the incessant and rapid passage of a to-and-fro current, then any obstruction which, according to Ohm's law, obstructs the flow, would obstruct the operation of the apparatus, whatever might be the nature of the receiver on which the electricity was to act when it arrived.

In this case a high resistance diminishes the quantity which flows through it. The current which is to "fill up" the plate of the Dolbear receiver starts from (or is drawn back to) the terminal 1 of the coil. It flows from that point for an excessively short period and back again for an excessively short period. If the line wire offered no resistance whatever to this flow, the potential of the receiver would rise as high and fall as low as the potential of the point 1, with which it is connected. If, however, the line offers such resistance as to seriously impede the flow, the full amount will not be able to pass to the receiver during the short time when the point 1 is at a high potential, nor to run out of it during the short time when the point 1 is at a low or negative potential, and the potential of the plate will not rise as high nor fall so low; that is, its range of variation will not be so great, as in the former case. If the conductor be broken, and the parts so far separated that one does not influence the other, there will be no flow; if the resistance be infinitely great, the flow and the consequent range of variation will be infinitesimal.

It is clear from this that Ohm's law (or such modification of it as applies to transient currents of high tension) applies to the case of Mr. Dolbear's apparatus. It applies because the apparatus as a whole depends upon the flow of a current of electricity, and because the control of the receiver by the transmitter depends upon that transfer of electricity which is known as a current.

The experiments Nos. 6, 7, 8 show that leakage, due to imperfect insulation, also affects the apparatus seriously. In this case it required a high resistance of 80,000 ohms to retain on the line electricity enough to work the instrument, though probably less might do it. An insulation resistance of one hundred ohms would be sufficient with the magneto receiver on a short line. The extreme high tension of the currents employed increases the difficulty of obtaining the high insulation required.

I have tried two other experiments which show, what indeed has been known for many years, that electrical instruments can work without the passage of a current from the actuating battery to the receiver, and with the current interrupted, provided only that the separate conductors are placed in such relations to each other that every electrical impulse employed in one causes a like electrical impulse in the next. Arrangements of this kind have been adopted in order to guard against earth currents, and for other purposes. This plan has been applied to the Atlantic cables from a very early day. It is due to Mr. C. F. Varley, and is described in an early English patent, and in his United States patent, No. 78,495, June 2, 1868. One form described in Varley's said patent, and also shown and explained in Preece and Sivewright's *Telegraphy*, p. 135, and Jenkin's *Electricity and Magnetism*, p. 335, is represented by the following diagram:—

In this arrangement no current from the battery B ever reaches the line; the cable is normally in a state of electrical equilibrium and at a zero potential.

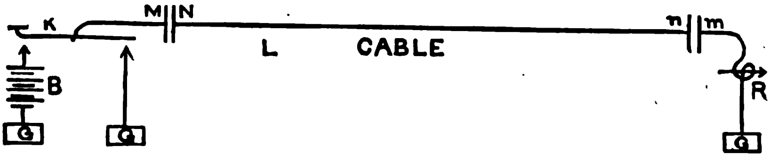

Fig. 12.

In describing this Mr. Jenkin says (p. 336):—

"The line L is attached to the insulated armatures N and *n* of two large condensers; the second armature M at the sending end is connected to a key K by which it can at will be connected with the battery B or with earth; the armature *m* is permanently connected through the receiving instrument R with earth. When, by the key K, M is connected with the positive pole, N is rendered negative by induction; a current flows from N to *n*; *n* becomes positive and *m* negative by induction; and to charge *m* negatively a short current flows from *m* to G through the galvanometer receiver R, making the desired signal in one direction; the current sent through R begins suddenly, is very small, and would gradually die out; the fall in the current is however accelerated by raising the key and putting M to earth . . . with this arrangement no electricity flows into or out of the cable but by induction; the charge in the cable is rearranged at each signal . . . Mr. Varley's system has the additional advantage that no permanent earth currents can flow through the line, for the line is not connected anywhere with earth."

The receiving instrument is a galvanometer which works by the influence of a current on a magnet. It may be placed as shown in the diagram or it may be placed in the line between *n* and N. The electrical change which here takes place is a current in the true sense. It is transient, but will work any delicate magnetic instrument, including a galvanometer, which is an instrument distinctively known as a detector and measurer of currents.

Mr. Pope states as follows (on p. 20 of his affidavit):—

"The two methods, in short, avail themselves of two wholly distinct properties of electricity or two wholly distinct electric energies, namely, the so-called dynamic electricity employed in Bell's system, and static electricity employed in Dolbear's system. Their energies differ first, in their intrinsic nature, secondly, in the effects they are capable of producing as regards their natures. The essense of the dynamic electricity is its motion, and the essence of the static electricity is its rest. Hence their respective names. As regards their effect each produces a manifestation of energy wholly different from that produced by the other. Dynamic electricity, by virtue of its motion, produces magnetism; static electricity, by virtue of its lack of motion, produces electrical attraction. These effects, as widely different as the causes which produce them, are respectively used by the two systems. A uniform and continuous magnetic attraction can only be produced from the conversion of electric energy by means of a continuous electric current traversing an uninterrupted circuit. If this circuit be interrupted, the magnetic attraction ceases. On the other hand a uniform and continuous electric attraction can only be produced by means of a continuous difference of potential, which is maintained by a continuous interruption of the conductor. If the circuit be closed, the difference of potential is no longer maintained, and the electric attraction ceases."

If Mr. Pope means by this that electricity at rest can attract and cannot magnetize, he is correct; if he means that a conductor through which a current of electricity is passing cannot attract a body not similarly charged, he is in error; if he means that in the operation of the Dolbear apparatus there is a single instant when electrical changes are not going on, he is in error; for incessant change is the law of its action just as much as when a magneto receiver is used. If he means that electricity does not flow to and fro between the transmitter and the receiver in the Dolbear apparatus, Fig. 2, as much, as rapidly, as often, as in the Bell apparatus, Fig. 1, he is in error. In Fig. 2, as in Fig. 1, a "linear conductor" is provided for that very purpose and none other; and it is as essential in the one case as in the other. The electricity does not stay at home, but travels from the transmitter to the receiver to work the latter.

He is quite right in saying that a continuous current is needed for "a uniform and *continuous* magnetic attraction," and that a continuous difference of potential is needed to produce "a uniform and *continuous* electric attraction." But he does not say, and I am sure that he would not say, that in either receiver the attraction is "uniform and continuous" or either, for in fact it is the unceasing *variation* in the attraction which produces the sound.

He says that a uniform and continuous magnetic attraction can only be produced by a current in an uninterrupted circuit. I infer from the rest of his affidavit that he means by this a ring circuit. Strictly speaking, he is right in this. But such *transient* magnetic effects as are needed to work a galvanometer or a telephone are practically found in conductors which are wholly insulated by means of condensers or induction coils. This is shown by the ordinary use of condensers in submarine cables, and by the experiments shown in the foregoing diagrams, 3, 4, 5, 6, 7, 8, 9, 10, 12. All of these experiments depend upon laws which are familiar, and I think that any electrician to whom they were suggested would at once perceive that they must result as I have found them to result.

He appears to say that a continuous difference of potential can only be maintained in an interrupted conductor. In this he is in error, for the potential of every part of a given conductor between the two points where the electric energy is applied is changed by the flow of a current; and if the supply is exactly equal to the outflow (so that a steady current is produced), the potential of every part thus charged remains unaltered. The Wheatstone Bridge is based on this property, and is particularly explained with reference to it by Jenkin, p. 243.

It is true that current, as current, does not exhibit the kind of electric attraction referred to and that potential, as potential, does not operate a magnet; but, in Mr. Dolbear's apparatus at least, change of potential and current necessarily accompany each other. It is true also that the magneto receiver can be worked with a current due to a moderate difference of potential, and that it is cheaper so to do; and that the alternating currents sent from the transmitting station will produce the high potential required for audible effects in the Dolbear receiver much more easily if the outflow or waste be small or cut off altogether by entirely insulating the line wire.

In fact, however, as I have already stated, the same transmitter in both operates by the same means and in the same way to cause an alternate flow and reflow of current along the conductor to the receiving station. This electricity has two properties and, placing the two instruments side by side in the same conductor, one property moves one and the other moves the other. The essential novelty to which speech is due, however, is not motion, but the peculiar character of the motion; and in both this is due to the fact that the electricity is not sent from one station to the other in a uniform and continuous flow, but in the form of "electrical undulations similar in form to the sound waves"; and this form is given to them by the voice of the speaker.

I am not sure that I understand the meaning which Prof. Trowbridge on p. 26 of his affidavit intends to convey. Submarine cables present the case where the electricity which starts from the transmitter never reaches the receiver in the ordinary sense, because the line is interrupted by one or more condensers. There is no "circuit," if that word is to be confined to a ring circuit, or conductor joined back to itself. This operates by the disturbance of the static charge of an insulated conductor; but the disturbance is manifested by or takes the form of a flow and reflow of electricity; and this is known as a current, and acts on magnets like a current of equal duration in a ring circuit. The linear conductor or line wire of the Dolbear form of telephone exhibits the same electrical operation as the cable, and both show electricity in motion. Prof. Trowbridge cannot mean, I think, to ignore these facts, and I therefore suppose him to mean that he did not know of any practical application of direct electrical attraction. In other words, the novelty which he refers to is a novelty found in the receiver alone. I also understand him to say that the principles involved in the receiver are well known, and have long been applied in electrometers for measuring purposes, but that he is not aware of any commercial application of the principle before Mr. Dolbear's apparatus.

In my first affidavit in this case I referred to the fact that previous to the date of Bell's patent electrical variations in the secondary circuit of an induction coil were utilized to produce sound by causing vibratory movements in plates. In this statement the defendants consider that I was mistaken. I had in mind three particular pieces of apparatus. First, the receiver of Dr. Wright, described by him in an article in the transactions of the Royal Scottish Society of Arts, 1860–1864, vol. vi., appendix, pp. 185–187. Second, a somewhat different condenser receiver of Dr. Wright described in *Ferguson on Electricity*, in 1867, p. 68; that description is repeated in Prof. Dolbear's book on the *Telephone*, published in 1877, p. 106, Third, the condenser described by Varley in his English patent, No. 1,044, of April 8, 1870. The two condenser receivers of Wright were placed in the secondary circuit of an induction coil, the primary of which was made and broken in the use mentioned by Ferguson by a Reis transmitter operated by the voice, and the statement made by Ferguson was that the musical note or pitch sung into the transmitter was reproduced at the receiver. In the Varley apparatus, one plate of the condenser was connected to one terminal of the secondary helix of an induction coil, while the primary circuit was made and broken by a tuning fork or other suitable arrangement. The purpose of the Varley was to reproduce in this receiver the pitch of the transmitter in a system of harmonic multiple telegraphy.

The defendants' affidavits refer to only the second apparatus of Wright. I still believe that the operation of those condensers of Wright and Varley was due to the attraction of the plates of the condenser for each other, as the potential of the one connected with the induction coil was raised or lowered, and thus that the nature of the operation was essentially the same as that employed by Mr. Dolbear in his receiver.

Mr. Dolbear and Mr. Pope, in their affidavits, state, if I understand them correctly, three things about the Wright receiver, which is the only one referred to. They say that the sound produced was not due to the charge and discharge of the condenser as those words are always understood in speaking of a condenser, but was due to the rupture of the dielectric by the disruptive passage of a spark from one plate to the other. The difference, of course, would be material in practice, because the condenser would be very quickly destroyed by the latter; and I cannot believe that Mr. Varley proposed to use an instrument which was so quickly self-destructive. The potential specified by Mr. Varley (50 volts) would be entirely inadequate to produce disruptive discharges in his condenser.

Mr. Dolbear and Mr. Pope also, if I understand them, say that the second apparatus of Wright did not exhibit what they call " mass vibrations" in the plate, and that the Dolbear apparatus does. Finally, they say, or rather give it to be understood perhaps, that the Wright receiver is not capable of reproducing speech, and that no man would be led to believe from what was known of its operation that it would reproduce speech. I think they are mistaken in these views.

I feel confirmed in what I stated in my former affidavit by the opinions expressed by a number of writers of authority who have referred to these condenser receivers and their operation, and by a series of experiments which I have performed on the subject. The first article of Dr. Wright in the transactions of the Royal Scottish Society described a receiver consisting of plates of zinc separated by insulating paper placed between them. He used language there which shows that he then believed that the noise was due to disruptive discharges from one plate to the other. In this, however, I think he was mistaken. The second apparatus of Wright was diffierently constructed: it was made of sheets of silvered paper placed back to back, the metal here being in the form of thin foil. The only description of this which I know of is from Ferguson, and it gives no indication or intimation that disruptive discharges were considered to be the cause. I presume that during the interval between the two publications, Dr. Wright had found the true cause. I am confirmed in this by the fact that Dr. Ferguson and Sir William Thomson took part in the discussion which followed the exhibition of Dr. Wright's first condenser.

Mr. Pope makes a statement from which one might infer that Sir William Thomson thought that the noise produced upon the discharge of a condenser experimented with by him was due to a disruptive discharge. The article by Sir William Thomson, to which I presume Mr. Pope refers, expressly states the contrary. In an article entitled "Sound Produced by the Discharge of a Condenser," dated 1863 and published in *Electrostatics and Magnetism*, p. 236, Sir William Thomson states that he has had occasion frequently to discharge a condenser consisting of two parallel plates of metal separated by a space of air about .007 inches (which, it will be observed, is precisely the character of the Dolbear receiver), and charged to a difference of potential equal to that of about eight hundred Daniel's elements. He then states that he remarked at the instant of discharge, a sharp sound which seemed to come from the interior of the case containing the condenser, "and which struck me as resembling a sound I had repeatedly heard before, when the condenser had been overcharged and a spark passed across its air space. But I ascertained that this sound was distinctly audible when there was no spark within the condenser." He then describes some experiments which he made and which satisfied him that the discharge was not due to a spark. He states that he has since ascertained that suddenly charging the condenser out of one section of cable charged for the purpose produces the same sound within the condenser; also that it is produced by suddenly reversing the charge of the condenser. That would seem to establish the fact, first, that the sound was produced, and second, that it was not due to a disruptive discharge. Sir William Thomson came to the conclusion that it was due to a specific effect of the electrical charge on the thin plate of air between two plates of metal. I am not prepared to say that this is not a cause, but I am well satisfied that it is not the principal cause in the action of condensers which are under consideration in this case. So far as it is a cause it would exist in the Dolbear condenser as well as in that used by Sir William Thomson.

The Wright condenser is compared with the Dolbear condenser by Mr. Dolbear himself in his patent No. 235,745, April 5, 1881, and he states the distinction between his apparatus and the second apparatus of Wright mentioned in Ferguson. He does not suggest in stating this distinction that the sound in one is due to a spark, but asserts the difference to be that the vibrations caused in his own are what he calls mass vibrations, and in the other are chiefly what he calls molecular vibrations, though I understand the statements in his patent to admit that mass vibrations may also be produced in the Wright receiver.

Mr. Varley, in his description of his condenser, uses the following language: he first describes the employment of his condenser for the purpose of interrupting the line and preventing the passage of any electrical current. "Impulses, however, passed through the condenser or the induction coil used, or both, and operated various forms of magneto receivers to produce musical notes corresponding to the rate of interruption by the tuning fork transmitter." He then states that the condenser itself may be used as a receiver. "If the condenser be made in the following manner, the rapid charges and discharges will produce musical sounds: Sheets of tin-foil (for example, one foot square) are separated by one or more sheets of thin dry paper; the first, third, fifth, etc., sheets are joined together; the second, fourth, and sixth, etc., also joined together. The odd numbered sheets are connected to a binding screw or terminal, and the even numbered sheets to another terminal. Such a condenser, consisting of from twenty to thirty sheets, will be found to be much agitated, and to produce a loud note with five hundred alternations of current per second, if the potential be fifty to a hundred volts." Mr. Varley was probably more familiar with the use of condensers than any one else at that time, because their extensive uses in telegraphy are largely due to his inventions and improvements in them; and the language he employs in describing the cause of the sound when the sheets were agitated is appropriate to a vibration of the sheets and entirely inappropriate to a disruptive discharge from one to the other.

In the *Telegraphic Journal* for Aug. 1, 1877, p. 178, a description is given by Mr. Varley of the operation of this condenser when used as a receiving telephone. He there states that the sound is due to a movement of the air produced by the approach of the plates to each other caused by their attraction when charged and their recession when discharged. This is the same view which I understand him to have announced in his patent in similar phraseology.

The Journal of the Society of Telegraph Engineers, for 1877, p. 476, gives an account of a condenser receiver apparatus exhibited by Mr. Adams. He unhesitatingly rejects the hypothesis that sound was due to sparks, since he found it to occur when a film of talc, he says, was substituted for the paper ordinarily used to insulate the plates from each other, and after using the condenser and producing the sound he ascertained that no hole had been pierced through the talc. He produced the sound both with a battery and with a small induction coil, the discharge of which did not possess sufficient energy to send a spark through the slightest thickness of air. He thought that the sound was due to the action of the electricity on the included air. In the discussion that followed the reading of this paper, Mr. Preece stated that he considered the vibrations to be due to the attractions of the plates for each other, as they were alternately charged and discharged, thus producing sound vibrations in the plates themselves.

S. P. Thompson, *Elementary Lessons in Electricity and Magnetism*, London, 1881, says: —

> Page 227: "When a condenser is discharged a sound is often heard. This was noticed by Sir W. Thomson, in the case of air condensers; and Varley even constructed a telephone in which the rapid charge and discharge of a condenser gave rise to distinct tones."
>
> Page 408: "Telephone receivers have also been invented by Varley and Dolbear, in which the attraction between the oppositely electrified armatures of a condenser is utilized in the production of sounds. The transmitter is placed in circuit with the primary wire of a small induction coil; the secondary wire of this coil is united through the line to the receiving condenser. In Dolbear's telephone the receiver consists merely of two thin metal discs, separated by a very thin air space, and respectively united to the two ends of the secondary coil. As the varying currents flow into and out of this condenser, the two discs attract one another more or less strongly, and thereby vibrations are set up, which correspond to the vibrations of the original sound."

I have also conducted a long series of experiments myself in connection with this point. Some of these were made as long ago as the early winter of 1880–1, others were made quite recently in connection with the present case. I have constructed receivers precisely similar to those described by Varley in his patent, where he gives detailed directions for their construction, and find, that on connecting their plates with the terminals of an induction coil, whose primary circuit is broken very rapidly several hundred times per second, the pitch of the note by the circuit breaker is perfectly reproduced, and this, whether I use a large coil capable of throwing a spark over an inch in length through the air, or a small one which could throw only a spark of about the twentieth of an inch in air. No piercing of the insulating plates occurred, and at the same time the plates of the condenser were vibrated very strongly, so that

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their motion could be felt by the fingers, and this when a heavy board one half inch thick was placed on the top plate, and even when a very considerable weight was put on top of the board. Similar results occurred with a receiver constructed precisely as described by Dr. Wright in his article in the proceedings of the Scottish Society, on his substituting two plates of zinc separated by paper. I tested for these vibrations with Mr. Bell's "vibration explorer," and found that it gave sound with them. This instrument is described in *Nature* of July 28, 1881. The Wright instrument was also found to work clearly when, for the paper insulator, I substituted a sheet or board of vulcanite three eighths of an inch thick, and so broad as to prevent the possibility of any electricity creeping around the edges. Using the Dolbear receiver with an induction coil and circuit breaker a similar sound is heard, the character of the sound being much the same in all these three receivers. I also constructed a receiver similar to that made by Dr. Wright as described in Ferguson, consisting of two sheets of silvered paper placed back to back, and I found that the pitch of the circuit breaker was reproduced. I succeeded with this instrument in producing a disruptive discharge through the paper, after which the receiver became silent. In cases where I produced a disruptive discharge between the plates, the character of the sound was very different from what it was under the normal action of the receiver in its charge and discharge in the usual way. When for the silvered paper of this apparatus I substituted shellacked paper backed with tin-foil, which effectually prevented the passage of a spark, the sound persisted so long as the circuit breaker remained in operation.

From these experiments, which are only a few selected out of many that I have made during the period indicated, I conclude that a spark or disruptive discharge is not the cause of the sound produced in the Varley, nor in the Wright apparatus.

I have also repeated in a modified form the experiments of Sir William Thomson already referred to. I have found that charging a condenser by connecting its terminals suddenly with the opposite poles of a battery of eight hundred cells, arranged in series, gave a distinct click, and that upon discharging the condenser through its terminals in the usual way another distinct click was heard. The hypothesis that the click is caused by a disruptive discharge, completely fails to explain its occurrence upon discharging the condenser, for previous to such discharge the difference of potential between two opposite plates is at its maximum, so that there is then the greatest tendency to discharge through the plate. On connecting the opposite plates of the condenser, the potential becomes the same in both, owing to a flow of electricity from the positive to the negative plate; and during the very short period in which discharge is taking place, the tendency to disruptive discharge through the plates is constantly diminishing. Yet the sound is substantially the same in this case as in the other, showing that the explanation suggested by Mr. Pope in his affidavit, but expressly rejected by Sir William Thomson, after experiment, is incorrect.

If I read correctly the affidavits of Mr. Dolbear and Mr. Pope, they do not deny absolutely that it was known previous to 1876, that sonorous vibratory motion of some sort in a plate could be produced by the electrical variations in the secondary circuit of a coil, but they state that mass vibrations, as they call them, were not known to be capable of production by varying the electric potential of two opposed plates, so as to produce sound. I do not know exactly what they mean by mass vibrations in this connection, nor what they mean by molecular vibrations.

Mr. Dolbear, in his book on *The Telephone*, p. 82, states distinctly that the difference which he attaches to the two phrases is a difference of more or less; and if the vibration is to be a sonorous vibration it must be so. The vibration of a body which is to produce sound must be a motion at the surface of that body in contact with the air, and what in the broadest term could be called mass vibrations is nothing more than that, though of course there may be differences in the range or extent of motion. There is such a thing known to physicists as molecular motion, that form of internal motion called heat, which does not cause any motion of the surface of the body perceptible as sound. There is undoubtedly a certain difference between the movement of a diaphragm supported at its edges and entirely free to move at its centre and the movement of a series of plates laid on each other where the motion of each is damped by contact with the others; but this is a difference, so far as the production of sonorous vibrations are concerned, of extent and not of character. It is well known that the plate of a telephone will produce sonorous vibrations when pressed firmly against the soft part of the ear, or when damped by pressing a piece of india rubber against it. Indeed, Mr. Dolbear has taken out a patent for pressing such a piece of rubber against the receiving plate of the telephone for the purpose of improving the sound.

Mr. Dolbear states in his patent of April 5, 1881, which I understand to be a patent on a receiver now in controversy, that, in his judgment, whatever vibrations occur in the Wright condenser are so damped by the plates as to be worthless for producing sounds. He does not anywhere refer to the Varley condenser, which must be equally well known to his advisers, because it was used in the Dowd suit in which Mr. Pope was expert witness for the defence. I suppose, however, that he would say the same of the Varley receiver that he does of the Wright; and I think that whatever applies to the one applies in every respect to the other. I do not understand him to say that he has ever actually tried to reproduce either sound or speech with either of these receivers. I have tried them many times for that purpose. I find that a small Wright condenser of his first form, made with zinc plates and enclosed in a case, similar to that used by Mr. Bell for his telephones, compares very favorably in its performance with one of the Dolbear receivers which I have already described, and that the larger condenser of Wright, constructed as directed in his article in the Transactions of the Royal Scottish Society, will readily reproduce speech. The Varley condenser, constructed as directed in Mr. Varley's patent already referred to, is also capable of reproducing speech, though less readily. I find that small instruments, constructed as described in Ferguson's *Electricity*, when placed in a suitable case will also reproduce articulate speech with tolerable distinctness and so as to be understood. All these condenser receivers have a somewhat peculiar quality of tone, similar to that obtained with the Dolbear, though somewhat different from that obtained with the magneto receivers. I find, moreover, that one of the Dolbear instruments will transmit speech when the spaces between the plates are filled up with layers of paraffined paper, and even when the plates are firmly cemented together by pouring melted paraffine into the space between them and allowing it to cool, although in both these cases the freedom of the vibration of the plates is so much checked that the results are much inferior to those obtained when used as constructed by Mr. Dolbear. From these facts I conclude that the same cause is operative in the Varley, in the Wright and in the Dolbear apparatus. Without denying the possibility of greater complexity in certain of the phenomena in all those instruments than is implied in Prof. Dolbear's description of the operation of his own, I consider that there is no doubt both that the transverse vibrations of the plate are practically operative because much alike in all those instruments, and that the effect of such action was recognized before 1876; and that the condensers made before 1876, or directed to be made for the purpose of transforming the electrical variations into sound waves will to day transform electrical undulations similar in form to the sound waves into corresponding sonorous vibrations, and thereby produce articulate speech. Of course I do not mean to assert that anybody produced articulate speech with either of these instruments before the date of Mr. Bell's patent.

Mr. Dolbear has departed from the precise construction of Wright and of Varley, and on the whole I think he has improved them. For their thin plates he has substituted a metal diaphragm, supported at its edges, which was shown and claimed in certain combinations of Mr. Bell's patent. He has added the sound box, which encloses the whole apparatus and gives the thin air space a central opening in front, which is described and claimed in Mr. Bell's second patent.

I have said that the vibration of the plates in the Wright, the Varley and the Dolbear was essentially the same. I do not consider, however, that precise identity in the particular manner of vibration is of importance to determine the identity of the Dolbear apparatus as a whole and the Bell apparatus as a whole, nor in determining the substantial identity of the Dolbear apparatus with the Wright or the Varley apparatus broadly as a means of producing sound. They both of them are condensers. They are charged and discharged as condensers are. The operation between one plate and the other — that is, the force exhibited between one plate and the other — is that force which is always present in condensers. The condenser as a source of sound was by Mr. Varley substituted for a magneto receiver as an equivalent for it. So Dr. Wright substituted his condenser in the Reis apparatus for the magneto receiver used by Reis as a means of converting into sound electrical vibrations produced by the voice. They did not convert them into articulate sound because the vibrations were not of a character which could produce articulate speech.

Mr. Dolbear's patent, No. 239,742, dated April 5, 1881, describes his condenser receiver and one manner in which he connects it. It contains the statements which I have referred to, and at the request of the complainants' counsel, I annex a copy of to my affidavit.

I have already referred to one paragraph of it and stated what I have found to be the cause of vibrations in the Wright condenser. In this patent Mr. Dolbear disclaims what is shown in the English patent 4,934, of 1877, that is, the patent of Mr. Harrison. Fig. 15 of that patent describes a receiver which he says "consists of two or more plates or disks to act as condensers." They are connected with the line wire and the battery, or with the secondary coil. He states that they are to be placed at a very small distance apart, according to the degree of potential.

This acts upon the same principle as the Dolbear, in my judgment, and I have transmitted articulate words with it. It is inferior to the Dolbear in this, that both plates vibrate nearly equally, which probably confuses the sound, and they are not enclosed in the sound chamber described in Mr. Bell's second patent.

In the said patent Mr. Dolbear also disclaims all that is shown in the patent No. 2,396 of 1878. That is the patent of Mr. Thomas A. Edison. Mr. Edison shows in that two condenser receivers, one, Fig. 8, which is of a very special and peculiar form, introducing also some electrical phenomena not found in the apparatus as constructed by Mr. Dolbear. Fig. 32 shows another form of condenser in which the transmitter also consists of a condenser made of a plate vibrated by the voice in front of a mass of silver highly charged. Mr. Edison calls this second one an electrophorus instrument.

My attention has been called to the fact that the defendants have put in evidence on their part two questions and answers from the deposition given by me in the Dowd case. The first one of these answers (34) is both true and complete. It is because no one had ever done what is there stated, and because, since Mr. Bell, Mr. Dolbear's apparatus does what is there stated, that Mr. Dolbear, unlike Mr. Bell's predecessors, is enabled to transmit speech; and that is one of the reasons why I consider that the Dolbear apparatus employs the Bell invention.

The second of those answers (35) does not apply completely to *all* cases without taking it in the sense and with the distinctions given in the following answer, 36, which the defendants did not introduce in evidence. Taking these answers together, I have stated what I believe to be the fact, and what is expressly stated in the first answer, that the connection between the transmitter and receiver must not be interrupted; and that the moving portion of the receiver must be constantly under the influence of, and guided by, the variations in the electric current caused by the motions in the transmitter, and that the electric circuit of the instrument must always present an uninterrupted path between the transmitter and receiver.

In my thirty-fifth answer I illustrated that by the case of a direct battery circuit. In my thirty-sixth answer I illustrated it by the case of conductors interposed between the transmitter and receiver but insulated from each other so that no current could pass from the one instrument to the other, but nevertheless placed in such relations to each other that an electric impulse would pass from one to the other. The case I referred to was where the induction coil was used. The case of a condenser is similar in this respect, and my thirty-sixth answer terminated with the statement of what was essential in the conductor in these words, "I think that the receiver is as constantly and fully under the influence of the transmitter as if the primary circuit current itself were transmitted," which is true of the Dolbear apparatus, and, if it were not, it would not transmit speech.

CHARLES R. CROSS.

STATE OF MASSACHUSETTS,
SUFFOLK, SS.

BOSTON, Feb. 11, 1882.

Subscribed and sworn to by the said Charles R. Cross, before me,

[SEAL] WM. W. KEITH, JR.,
Notary Public.

Extracts referred to in Affidavit of Prof. Cross.

Prof. Amos E. Dolbear, in *The Telephone*, Boston, 1877, says: —

Page 80: "When a membrane vibrates, its motion is generally perceptible to the eye; and it may have a great amplitude of motion, as in the case of the drum."

Page 82: "The vibration of a membrane and that of a solid differ chiefly in the amplitude of such vibration. The scratch of a pin at one end of a long log can be heard by an ear applied to the other end of the log; but every molecule in the log must move slightly; and there are all degrees of movement between that visible to the eye, which we call mass motion, and that called molecular, simply because we cannot measure the amplitude of the motion."

Page 106: "Dr. Wright found that a sound of considerable intensity could be obtained by passing the interrupted current through the primary wire of a small induction coil, and placing a conductor made of two sheets of silvered paper placed back to back in the secondary circuit. The silvered paper beomes rapidly charged, making a sound that can be heard over a large hall, and having the same pitch as the sending instrument."

Page 114. Prof. Dolbear describes Mr. Bell's magneto transmitter and receiver, and says: —

"This was the instrument exhibited at the Centennial Exposition, at Philadelphia, and concerning which Sir William Thomson said, on his return to England, 'This is the greatest by far of all the marvels of the electric telegraph' . . . This was the first speaking telephone ever constructed, so far as the writer is aware; but it was not a practicable instrument: many sounds were not reproduced at all, and, according to the report of the judges at the Philadelphia Exposition, one needed to shout himself hoarse, in order that he might be heard at all."

Robert M. Ferguson, *Electricity*, London and Edinburgh, 1873. The concluding part of this author's description of the Reis telephone is as follows: —

Page 258: "Suppose a person to sing a note at the mouthpiece, which produces three hundred vibrations a second, the circuit is broken at the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sending apparatus produces a current in the secondary circuit, which charges and discharges the condenser, each discharge being accompanied by a sound like a sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall."

Extract from English Patent of C. F. Varley, No. 1,044, *April* 8, 1870. — "There are various ways in which the wave signal receiving apparatus may be constructed, although that which I have already described I prefer; thus the condenser itself may be the receiving instrument.

"If the condenser be made in the following manner, the rapid charges and discharges will produce a musical sound: Sheets of tin-foil (for example, one foot square) are separated by one or more sheets of thin, dry paper. The first, third, fifth, etc. sheets are joined together; the second, fourth, sixth, etc. also joined together. The odd-numbered sheets are connected to a binding screw or terminal, and the even-numbered sheets to another terminal. Such a condenser, consisting of from twenty to fifty sheets, will be found to be much agitated, and to produce a loud note with five hundred alternations of current per second, if the potential be fifty to one hundred volts.

"In constructing the dry-paper condensers, the following method seems to answer best: —

"Very thin, uniform paper is dipped in shellac varnish, coated on one side with gold leaf and then dried. The non-gilt surfaces of two sheets of paper are put together, so as to leave the gilt surfaces outside. The tin-foil plates are placed outside of these, and built up in the usual manner, connecting the first, third, fifth, seventh, etc. plates to one armature of the condenser, the second, fourth, sixth, eighth, etc. being joined to the other armature of the condenser."

Page 564: "I also claim the construction of electric telegraphs with, at the transmitting station, an instrument capable of originating in the line wire a succession of rapid and regular electric waves, and at the receiving station a condenser consisting of thin sheets capable of being agitated by such waves."

Royal Society of Arts, *Transactions*, 1860–64, vol. vi; Appendix, pp. 185–187. (185.)

The following communications were made: —

1. On the electrophone and some of its applications, by Horace Strethill Wright, M. D., F. R. C. P., with illustrations.

Dr. Wright having described to the society the mode proposed by the late Mr. Sturgeon for producing shocks by a voltaic pile charged with water only, and stated that Mr. Sturgeon had contemplated the application of the same method to the magneto-electric apparatus of Saxton and Clarke, stated that in 1842, he (Dr. Wright) had contemplated an induction coil of great intensity, to which he had applied the apparatus of Sturgeon, — a condenser of coated oilskin. This he had afterwards changed for a condenser of coated mica. While employed on the above experiments, he had noticed the production of very loud sounds by certain forms of the apparatus, and had set himself to determine the best form for a sonorous condenser or electrophone for the production of audible sounds by such induction currents, and proceeded: —

> "After many experiments I found that the form laid upon the table gave the best results. It consists of a plate of sheet zinc slightly curved, so that when resting on a hard wood table its ends vibrate freely. On this plate is laid one or more sheets of cartridge paper and on the cartridge paper a pile of three or four zinc plates, the upper plates being curved so as to vibrate freely when resting on the succeeding ones below. When the instrument is connected with a small coil, the poles of which afford a spark almost inaudible, and about one sixteenth of an inch in length, it becomes charged with each impulse of current, and discharges itself through the slightly conducting paper; each discharge being attended by a sonorous tap given out by the whole mass of metal thrown into vibration, and the rapid succession of taps producing a continuous musical tone, which, by using a powerful battery with a coil, may be deepened into a loud roar."

Figures and description found on page 186.

After some remarks by the president, Dr. Ferguson, and Mr. Thomson, and some additional observations by Dr. Wright, the communication was remitted to the same committee as on his two previous papers read at last meeting.

Extract from Patent of A. E. Dolbear, No. 239,742, *April* 5, 1881.

"I am aware of the apparatus mentioned as used by Dr. Wright in 'Ferguson's Electricity,' published by William and Robert Chambers, of London and Edinburgh, in 1867, pp. 258 and 259, in which two sheets of paper, silvered on one side, were placed back to back, and connected with the two ends of an induction coil, the primary circuit of which contained a Reis transmitter; and I disclaim that apparatus. My receiver differs from it in that the sounds transmitted are reproduced by the mass vibrations of one of the terminals; while in the Wright receiving apparatus the sound produced was mainly if not altogether due to molecular motion, and not to mass vibrations.

"Moreovor, Wright's sheets of silvered paper were so arranged that each would damp any mass vibrations of the other; and in his apparatus any slight mass vibrations, even if not wholly damped, would be necessarily so irregular as to be worthless as a means of reproducing sounds. The fact, also, that the mass vibrations of each sheet damped those of the other sheet would make all the mass vibrations worthless for this purpose.

"I am also aware of English patents, No. 4,934 of 1877, and No. 2,396 of 1878, and disclaim all therein shown."

AFFIDAVIT OF GEORGES D'INFREVILLE IN REPLY.

I, Georges d'Infreville, having been duly sworn, on oath depose and say: My age is thirty-six years; I have been studying electricity and electrical apparatus, particularly telegraphy, for more than twenty years. For nearly ten years I have occupied myself as electrical engineer or consulting electrician in New York. I have been employed as electrician by the Atlantic and Pacific Telegraph Company, and am now in the service of the Western Union Telegraph Company as electrician. I have made an attentive study of electric speaking telephones for several years past. I am familiar with Mr. Bell's two patents, 174,465 and 186,787, and have had constructed in my shop and used telephones made in accordance therewith, while serving as expert for the National Bell Telephone Company. I know the Dolbear condenser receiver described in the affidavit of Mr. Davis and arranged as described by Mr. Buck, and have used such instruments.

I find in Mr. Dolbear's affidavit the following passage: —

> "It is true that by Mr. Bell's method the air waves produced in speaking are caused to vibrate an instrument which holds the electric circuit under its control constantly, so that whatever movement of the diaphragm at any instant may be made will be converted into a corresponding electrical variation on the line wire, and I do the same."

I add to this the facts stated elsewhere in the defendants' affidavits, that both Mr. Bell and Mr. Dolbear employ these electrical variations when they have reached the receiving end of the line, to there produce sonorous vibrations in an elastic metal plate, and thus cause the listener at the receiving station to hear and understand a sound which is the same as that of the word uttered into the transmitter.

Upon the facts thus disclosed by the defendants' affidavit, I am of the opinion that the apparatus of Mr. Dolbear is substantially the same as the apparatus described in Mr. Bell's patent 174,465, referred to in his fifth claim, and transmits speech by and in accordance with the method disclosed in that patent, and referred to in that claim, which is as follows: —

"The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

I have read the defendants' affidavits. I think they contain some erroneous and some partial or incomplete statements of fact. But the matters of fact therein stated, if true, would not change my opinion, and correctly understood, they do not tend to contradict the opinion I have already expressed.

I will state some of the reasons which lead to this conclusion.

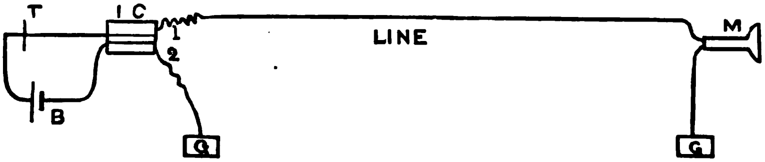

Fig. 1.

Fig. 1 is intended to represent a Bell speaking telephone apparatus such as is in ordinary use, and is, in my opinion, if correctly understood, substantially an apparatus described in said Bell patents and referred to in its fifth claim.

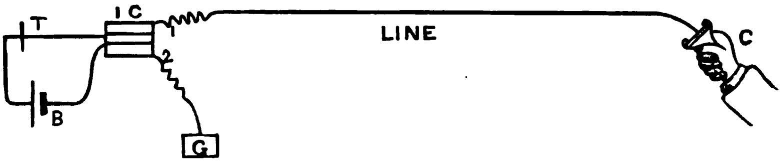

Fig. 2.

Fig. 2 is intended to show a Dolbear apparatus.

In each apparatus I find the following features in common: —

A primary circuit, included in which is a battery B, a variable resistance transmitter T (of which the Edison is a well-known type), and the primary helix of an induction coil, I. C. This induction coil has a seondary helix, one terminal of which goes to earth at G, and the other terminal is connected to a line wire which goes to the distant station.

When speech is transmitted by this apparatus I find the operation of these parts and the electrical phenomena which take place in them to be as follows: —

The voice vibrates the plate of the transmitter T This varies the electrical resistance of the transmitter, but never interrupts the circuit. This varies the strength of the current in the primary helix of the induction coil. These variations produce corresponding currents in the secondary helix. One of said variations, considered by itself for instance, raises the potential of one terminal of the coil and lowers the potential of the other terminal; this causes a flow or current of electricity from either terminal along any electrical conductor which leads from it or joins it to a body of different potential, and this changes the electrical condition of the distant and every other part of that conductor; moreover, the voice uttering a word causes the plate of the transmitter to vibrate in accordance with the special "form" or character of the series of vibrations which constitute that word; this causes the resistance to vary in accordance with said character; this causes the variations in the primary conductor and helix to vary in accordance therewith; this causes the currents thereby induced in the secondary helix to correspond therewith in the character of their variation; this in turn causes the rises and falls of potential at the terminals to obey in their characteristics the same series of variation, and this compels the current due to the varying potential of the terminal the conductor is connected with to vary according to the same form or character.

This operation and these phenomena take place whenever a word is uttered near to the transmitter of either apparatus; and the transmission of that word to the receiving station so as to be there recognizable as the same word could not be accomplished in either apparatus unless this did so take place.

Each apparatus also has a receiver whose office it is to enable the electrical changes which are thus produced to reach the receiving station, to be there ultimately converted into sonorous air vibrations corresponding in form. In each, the receiver contains a metal plate which the said electrical changes cause to be attracted more or less strongly towards a neighboring and practically immovable body and these motions of the plate correspond in form or character to those electrical changes and produce sonorous vibrations of corresponding form or character in the air.

That the respective receivers should so act is necessary for the transmission of speech in each apparatus.

All this being as I have stated, I am of opinion that all other differences which I have been able to conceive of after reading the defendants' affidavits are immaterial as regards the embodiment in the Dolbear apparatus of the invention of Mr. Bell, defined in said fifth claim of the patent 174,465.

The currents which I have spoken of are not continuous currents, in the sense of a continued flow in one direction. Such currents are not necessary, and in ordinary practice are not used in any of the known forms of the speaking telephones. The currents which accomplish the transmission of speech in the speaking telephone are transient currents of excessively short duration, rapidly alternating in their direction, continually varying in their strength, but never ceasing to move while speech is being transmitted. The arrangement of Mr. Dolbear's conductors permits of such currents; they are present in all electrical parts of his apparatus and they are essential to its operation.

I do not indeed find that Mr. Bell's said fifth claim is limited to "currents"; but I do not find first, that the electrical changes which take place in Mr. Dolbear's apparatus are not prevented by anything in the arrangement of his conductors from being "electrical undulations similar in form to the vibrations of the air accompanying vocal or other sounds," and that in fact they are accomplishd by and cannot take place without the intervention of currents.

The property of electricity which Mr. Dolbear makes use of in his receiver is a property which was well known before 1876; it had before that day been practically used in many testing instruments, and had been applied by Dr. Wright and by Mr. C. F. Varley to converting electrical variations into sound waves. The mode of operation of the condenser receiver of Wright described in Ferguson's *Electricity* and of the condenser receiver of Varley described in his English patent No. 1,044, of April 8, 1870, are the same in kind as that of the condenser receiver of Dolbear. The differences are changes of construction in the nature of improvements merely.

I believe firmly that the cause of the sound in those instruments of Wright and Varley was not disruptive discharges between the plates. The Wright condenser was of silvered paper; the Varley condenser was of foil. Varley states that he used five hundred alternations of current per second; Wright would, I infer, employ about the same number. If there were disruptive discharges, the instruments would be destroyed, and would cease to be condensers in a time much less than that required to perform the shortest experiment.

I have performed the following experiments: —

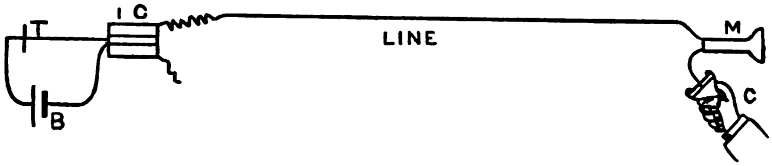

Fig. 3.

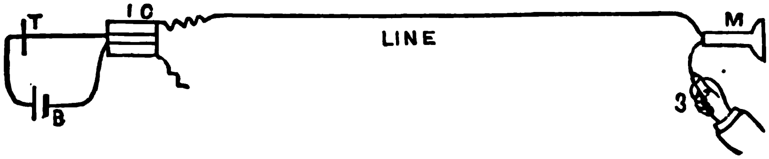

Fig. 4.

In Fig. 3 I inserted a Bell magnetic receiver by a loop in the Dolbear line conductor. Both the magneto and the Dolbear yielded articulate speech.

In Fig. 4 I left both ends of the circuit open; *i. e.*, using a single conductor not grounded with any body. I obtained articulate speech with a Bell magneto receiver thus connected, though it was feeble. Upon holding the farther terminal 3 of the magneto receiver in my hand the speech was much improved.

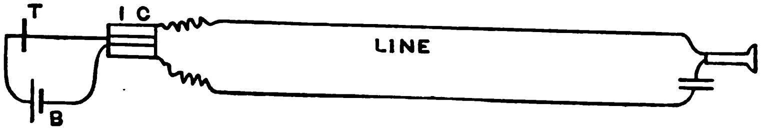

Fig. 5.

I then tried a Wright zinc plate condenser connected as shown in the diagram Fig. 5. I obtained articulate speech both in the magneto and in the Wright condenser. I then took out the Wright condenser and replaced it by a Varley condenser. I got articulate speech with this also.

I have examined the diagrams of the other experiments testified to by M.. Cross in his affidavit in reply. I have not performed them because it has not been convenient for me so to do. I believe from my knowledge of electrical phenomena that the results would not be other than what he has stated.

GEORGES D'INFREVILLE.

Sworn to before met this tenth day of February, in the year 1882.

[SEAL] WM. ARNOUX, *Notary Public,*
Kings and New York Counties.

AFFIDAVIT OF PROF. ARTHUR W. WRIGHT, FOR COMPLAINANTS, IN REPLY.

I reside in New Haven, Conn., and am professor of molecular physics in Yale College, which position I have held since 1872. Previously to that date I was professor of physics and chemistry in Williams College, Mass., from 1869 to 1872. My whole time since 1865 has been devoted to the study and teaching of physics and chemistry, and throughout the whole of this period I have given especial attention to the study of electricity as respects both the theory and its practical applications.

I am familiar with most of the forms of apparatus which have been devised for the electrical transmission of articulate speech, and have made experiments with many of them. The form of apparatus invented by Prof. A. Graham Bell, known as "the telephone," has been known to me from near the date of its invention; and I witnessed some of the earliest public exhibitions of it given by Mr. Bell in this city. I have also personally made many experiments with this apparatus, and well understand the details of its construction, the conditions for its successful operation, and the electrical principles involved in its action. I have read Mr. Bell's two patents, 174,465 and 186,787, and believe that I understand the inventions therein set forth and claimed. I shall confine my remarks particularly to the invention defined in claim five of patent 174,465.

The instrument devised by Mr. Dolbear for a telephonic receiver is well known to me; and I am acquainted with the general mechanical arangements which constitute the telephonic apparatus described in the specifications of his patents Nos. 239,742 and 240,578. Without entering into an extended comparison, it may be sufficient to consider the points in which, according to the claims made for the Dolbear telephonic apparatus, the two forms of apparatus are alleged to differ in such a way as to render the latter and its operation an independent and novel method for the electrical transmission of articulate speech.

As I understand the statements made in the affidavits for the defendants, no claim of such novelty is made for any parts of the Dolbear apparatus other than the receiver, or for any details in the operation of the system except such modification of the electrical conditions occurring upon the line as are alleged to result from the substitution of this receiver for the receiving instrument employed upon lines which they say are operated under Bell's patents; that, in short, the Dolbear telephonic apparatus as a whole is substantially identical with the Bell apparatus as a whole, except in the substitution of a part known as the Dolbear receiver for a corresponding part, namely, the magneto-receiver of Bell, and as regards such changes of the electrical conductors as in ordinary practice accompany and they say necessarily accompany the selection and use of one receiver or the other.

It is claimed by the defendants that the action of electricity in the two forms of apparatus is specifically different; that in the Dolbear apparatus it is employed in the form of a static charge, while in what they call Bell's system it is dynamical electricity which is used to produce the effects desired. So far as the direct action of electricity in moving the vibrating plates is concerned, a difference in the two systems undoubtedly exists; but here the distinction stops. In both cases the electricity which passes over the wire to the receivers is subject to incessant variations.

According to the fifth claim of Mr. Bell's patent 174,465, he transmits speech by causing those electrical variations to conform in their character to the changes in the acoustic undulations which are set up in the production of sound or articulate speech; and Mr. Dolbear's apparatus causes all the electrical variations which take place in it to conform in their character to the same changes. If this conformity did not exist in the operation of the Dolbear apparatus, it would not transmit speech. In the apparatus of both, these variations of electricity upon the line are true currents of limited duration; and this is necessarily true of all speaking telephone apparatus whatever.

When a long insulated wire is connected at one end with one pole of a voltaic battery, the other pole of which is grounded, a rush of electricity into the wire takes place until the wire has become charged to the tension of the battery. On breaking the connection

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with the latter and putting to ground that end of the wire which was first connected with the battery, a rush of electricity in the opposite direction takes place and the wire is discharged. These effects can readily be detected by means of a galvanometer, through which the electricity passes as it enters and leaves the wire. When the latter is short and well insulated, the duration of the passage of the charge is very brief; on the other hand, it is increased if the wire be made very long and of high resistance, or if the remote end is connected with a conducting body of some capacity. If the wire is touched to the collector of an electrical machine, or any conductor having a charge of statical electricity, similar effects follow. The charge of statical electricity, as it moves over the wire, when a path is provided for it to move over, becomes dynamical electricity, and is a true current of a transient character. Now if in experiments upon discharges of statical electricity the remote end of the wire, instead of being free, is connected to an insulated conductor, the electricity passes into the latter, and the quantity which thus passes is dependent upon the capacity of such conductor. The movement in the wire is of the same nature as when the latter is connected with the earth. The fact that the wire which conveys the electricity to the Dolbear receiver is not connected through the latter to the earth makes no material difference in the electrical condition of the line wire as compared with that existing under what the defendants call the Bell system, except as regards the quantity of electricity passing, inasmuch as the metal plate of the receiver has sufficient capacity to admit of an electric accumulation which is substantially sufficient for telephonic work. In both cases the currents are transient, in both they are essentially the same in nature and must follow the same laws.

It is claimed by Mr. Dolbear that the form of his receiver, by making a complete break in the line wire, while in what he calls the Bell system the latter is continuous through the receiver to the ground, introduces such a difference of condition that the electricity passing in the former case does not obey the law of Ohm, while in the Bell system it must and does follow that law. This claim involves an error as to the application of Ohm's law, in respect to which an important point has been overlooked. The law commonly known as Ohm's, which is the mathematical expression of the fact that the current strength varies directly as the electro-motive force and inversely as the resistance, is only true for a current which has attained what was called by Ohm (*Die Galvanische Kette matematisch bearbeite*, Berlin, 1827. Translation in Taylor's Scientific Memoirs, vol. 2, Art. XIII.), *the permanent state:* that is, which passes steadily, without interruption or variation. When the resistance of the circuit is increased the current strength diminishes, and when the resistance becomes infinite, as in the case of an open circuit, such a current ceases to exist; and this constitutes merely a limiting case under the same general law above quoted. But steady currents are not and, for obvious reasons, cannot be employed in the transmission of speech.

For the varying and transient currents, or electrical undulations, which are employed equally in the Bell telephone and the Dolbear telephone, the simple law above quoted does not apply. Such currents are shown by Ohm to follow a far more complicated law, which, however, must hold equally well for all forms of apparatus using undulatory currents of the same transient character.

I do not mean to say that increase of electro-motive force does not increase the current, or that increase of resistance does not diminish the current, on a telephone line. What I mean is, that since we here have to deal with currents not in the "permanent state" but in the "variable state," the elements of change and time enter as such important factors that Ohm's law, which expresses the whole truth as to the one kind of current, does not express the whole truth as to the other. In this respect the currents in what the defendants call the Bell system are found in the variable state as much and to the same extent as they are in what they call the Dolbear system. The asserted discrimination between the two forms of apparatus, as respects the application of Ohm's law to the currents on the line wires, has no significance for steady currents, which are useless for telephonic purposes; and in the case of the undulatory currents used it does not exist.

It is further claimed on behalf of the Dolbear apparatus, that, as the line is broken by the interposition of the receiver, while in what the defendants call the Bell system the line wire is continuous with that of the receiver coil, and through this is connected with the earth, that the former employs an open circuit, and the latter a closed circuit, and can only operate upon such a circuit; and it is contended that this constitutes a material difference. That this distinction can justly be made as respects the ordinary voltaic currents is obviously true, but as respects the transient currents, or electrical undulations, which alone are operative in the reproduction of articulate speech, the conditions are totally distinct. A new and essential factor in the problem enters, in the fact of induction. When the electrical status of a conducting body is made to vary, corresponding variations are produced in a neighboring conductor by induction, either electro-static or electro-dynamic, or both, according to the form and capacity of the second conductor and its relation to, or connection with, other connecting bodies or the earth. In the Dolbear receiver, it may be admitted that the varying potential of the plate attached to the line wire causes variations in the potential of the second plate, resulting in attraction. But this is not all. If this second plate is connected by a wire to the ground, to a second receiver of the same kind by an insulated conductor, or to one pole of a Bell receiver, the variation of potential in the first plate of the first receiver aforesaid causes, by induction, a passage of electricity in the connecting wire to or from the second plate of that receiver, thus giving rise to electrical undulations or transient currents in this wire.

If a series of undulations proceed from the transmitter over the line wire, a similar series of undulations is produced in the wire issuing from the second plate of the Dolbear receiver above mentioned; and the separate impulses or undulations of this second series will necessarily bear the same relation to one another, as respects time, phase, and duration, as do those upon the line wire to each other. If the undulations in the first wire are of such a character that, acting upon a suitable receiver, they will produce intelligible speech, those in the second wire are equally fitted to bring about this result, and will do it. This conclusion is clearly indicated by theory; and I know it to be true from many experiments, of which the following may serve as examples: In these experiments, the transmitting apparatus was placed in a distant room, separated by three doors from the place where the observations were made, so that no sound could be heard directly. Two independent circuits between the rooms were used, one being of the ordinary office wire, insulated by a double coating of paraffined cotton thread, the other a somewhat larger wire insulated by a very heavy coating of kerite. Both circuits were well insulated. Usually, one pole of the induction coil was grounded by means of a wire passing to a gas pipe, and the other connected to one of wires above mentioned, which represented the line wire, and is so designated in the following paragraphs: —

Occasionally, both wires were used, so as to complete a return circuit. A separate circuit conveyed the current from a battery to the primary wire of the coil and the transmitter.

First. A small induction coil provided with a vibrating circuit-breaker being used, one of the poles of its secondary coil was joined to the line wire, and the latter at the receiving end to one of the terminals of a Bell telephone M, the other terminal of which was grounded. The undulations produced in the wire by the motion of the break-piece caused the telephone to give forth a loud sound of the same pitch as that produced by the break-piece itself when vibrating. The arrangement of circuits employed is illustrated by the diagram, Fig. 1, the transmitter T of which, in the primary circuit of the induction coil I C, was replaced by the vibratory circuit-breaker of the coil.

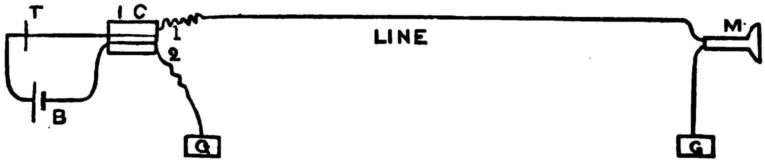

Fig. 1.

I then varied the arrangement by the employment of two Æpinus condensers, composed of thick brass plates without the glass panes; that is, with only an air space intervening. The plates were circular and in the larger apparatus were six and three quarters inches in diameter; those of the other condenser were three and one quarter inches in diameter. During the experiments the condensers were separated by a distance of from six to eight feet; the line wire was connected to the lower plate of the large condenser, while the wire from the earth was united to the corresponding plate of the smaller.

To the other plates, which could be raised or lowered upon their supports, were fastened the conducting wires of the telephone, which was thus inserted in a wire conductor between them. When the coil was set in operation, sound was heard from the telephone as before, and was still distinctly audible when the parts of the large condenser were separated by a distance of more than one foot, and those of the smaller four inches or more. The diagram Fig. 2 shows the arrangement of conductors employed.

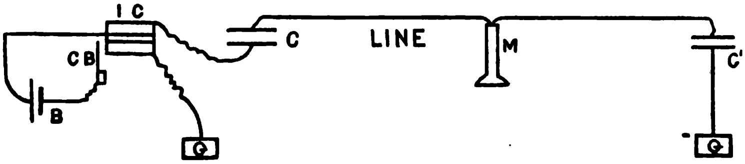

Fig. 2.

The pitch and timbre of the sound were the same as when the telephone was inserted directly in the circuit of the induction coil, the only essential difference being in the intensity, which varied in a marked degree with the distance between the condenser plates. This shows that the undulations set up in the telephone wire by induction were of the same character as those in the wire from the coil, though connection between them was prevented by an air space of several inches.

Second. A carbon transmitter being placed in the primary circuit of a similar but larger coil, which was placed in the distant room, and the same arrangement being used as above described, words spoken into the transmitter were distinctly heard and perfectly understood in the telephone, while the condenser plates were separated, though the distance between them was much smaller than before.

Third. I then arranged instruments and conductors as shown in diagram Fig. 3.

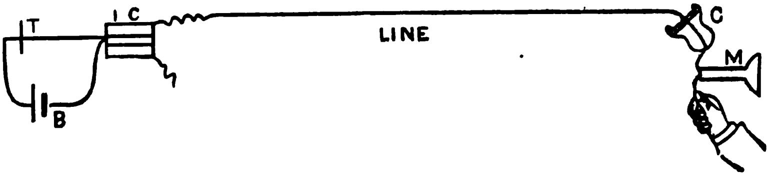

Fig. 3.

The wire from the coil, that is, the line wire, being connected to one plate of a Dolbear receiver, the second plate of the latter was connected with one terminal of a Bell telephone, the other terminal of which was grounded, or simply touched with the finger. Here the Dolbear receiver played the same part as the large condenser in the preceding experiment. Speech was distinctly and easily heard from both receivers.

Fourth. I then arranged conductors and instruments as shown in diagram No. 4.

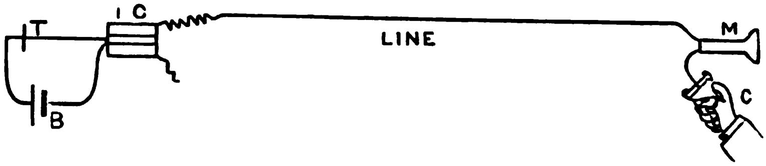

Fig. 4.

The positions of the two instruments were interchanged, the Bell telephone being now inserted in the line, the Dolbear receiver in the ground circuit of the former; the result was the same as before, except that the articulation of the Dolbear receiver was apparently clearer than when used alone upon the line.

Fifth. I then adopted the arrangement of conductors and instruments shown in diagram No. 5.

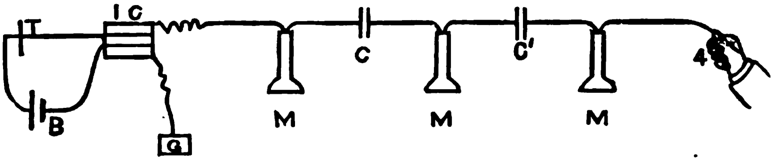

Fig. 5.

Three Bell and two Dolbear receivers were inserted into the line in series, and so that the Dolbear instruments were between the Bell receivers, the last one of the latter being arranged so that its terminal (4) could be grounded or left free. When words were pronounced at the transmitter they were reproduced in all of the receiving instruments; and this was true even when the terminal wire (4) was left free or insulated. When it was touched with the finger or otherwise grounded, the same effects were observed; and the sound, otherwise unchanged in character, was simply made more intense, especially from the last telephone of the series, as was to be expected.

The purport of these results is obvious. They prove conclusively that the break in the line conductor made by the Dolbear receiver, so far from presenting a bar to the transmission of the electrical undulations, permits them to pass with the utmost facility, merely serving slightly to diminish their intensity. This diminution is the necessary consequence of the fact that the charge produced through a dielectric is always less than the inducing charge, and depends also in part upon the greater or less capacity of the body in which the induction takes place. The air space has then merely an effect analogous to that of a resistance introduced into the line; and several such breaks may be introduced without preventing the reception and distinct understanding of speech from telephonic receivers placed beyond them. To state this result in other words, the Dolbear circuit, which for continuous currents is an open circuit and permits no passage of electricity, freely transmits through all its parts electrical undulations caused by the action of the transmitter, substantially unchanged in all those particulars which are essential to the reproduction of speech, as would a closed circuit with somewhat increased resistance. Here also the distinction between what the defendants' affidavits call an *open* and what they call a *closed* circuit, as to the effects produced, falls to the ground.

Further, these experiments have an important bearing upon another claim made for the Dolbear instruments, which is, that the electric variations which reproduce speech in this receiver are incapable of working the Bell receiver, and, *vice versa*, that the currents which cause speech in the latter apparatus cannot work the Dolbear receiver, regard being had of course, not simply to the direct action upon the vibrating plates, but to the whole operation of the electrical variations existing. It is abundantly proved by the experiments that the currents which are efficient in one case are also efficient in the other.

The receiving apparatus. I understand Mr. Dolbear in his affidavit to make the claim that he was the first person to discover the fact that variations in the electrical potential of a metal plate, as for instance the plate of a conductor, could be used to set this plate into vibration in such a manner as to produce sound and reproduce articulate speech. Waiving for the present any discussion of the priority in the invention of the particular mechanical arrangement of the receiver, the question as to the novelty of this application of electricity may be determined by an examination of the history of observations upon the sound emitted by condensers, and of the use of condensers of special construction for the express purpose of producing sound. There is involved in this also the question whether the attraction caused by the statical charge is the sole and sufficient cause of the vibration and the consequent production of sound.

In a letter to Prof. Tait, dated Oct. 10, 1863, reprinted in the volume entitled *Papers on Electro-Statics and Magnetism*, 1872, p. 236, Sir Wm. Thomson states that he had remarked a sharp sound on discharging an air condenser, that he had satisfied himself that no spark discharge across the air space took place, both by the entire absence of luminous phenomena and by the fact that the whole discharge "took place fairly through the 2,000 yards of fine wire constituting the galvanometer coil." He further says: "I have since ascertained that suddenly discharging the condenser out of one of the specimens of cable charged for the purpose produces the same sound within the condenser; also, that it is produced by suddenly reversing the charge of the condenser." He states the following conclusion: —

"Thus it is distinctly proved that a plate of air emits a sound on being suddenly subjected to electric force or on experiencing a sudden change of electric force through it."

In the year 1870, Mr. C. F. Varley obtained a patent (English patent, No. 1,044) for a telegraphic apparatus in which the sound emitted by a condenser is utilizied. In this system the current from a battery traverses the primary wire of an induction coil. The induction currents generated in the secondary wire of the coil are conveyed by a wire from one of its poles (the other being grounded) to one plate or set of plates of a condenser. The other plate of the condenser is connected to a line wire. At the other end, the line wire is connected to one terminal of a condenser at the receiving station, the remoter terminal of this condenser being connected to the ground.

The following diagram shows the arrangement of conductors employed by Varley.

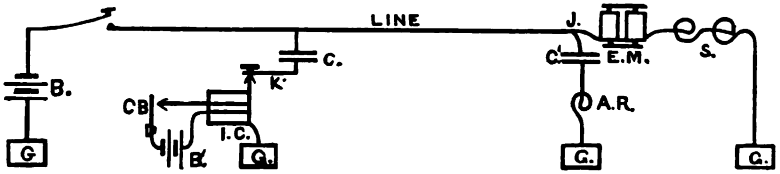

Fig. 6.

K was the key of a Morse transmitter at the sending station; S was a Morse sounder or other equivalent receiver at the receiving station; C and C′ were two condensers; C B was a vibrating circuit-breaker at the transmitting station; K′ was a Morse key; A R was an acoustic receiver; E M was a large and sluggish electro magnet. Mr. Varley's statement of the operation was, that the signals sent by the Morse key K would work the Morse receiver S, but were not sufficiently sharp and rapid to produce effects on or through the condensers. On the other hand, the rapid and sharp "wave signals" sent by the harmonic transmitter C B, which broke the circuit several hundred times a second, would pass through the condenser C by induction, would reach the point J, would not be able to effectively pass the sluggish electro-magnet E M, but would pass to the condenser C′, then inductively affect or pass through that instrument to the ground, operating the acoustic magnet receiver on its way.

Confining our attention to what Mr. Varley calls the "wave signals," which are those sent from the induction coil I C, and which operate the receiving condenser C′, or the receiver A R, we find that in this apparatus the electrical impulses produced by induction in the secondary wire of the coil alone pass over the line wire, as no part of the battery current can enter it. Mr. Varley proposes to utilize these currents to work acoustic magnetic receivers of various forms, for which they are well suited ; he also suggests the use of the condensers themselves for producing sound, as the following extract from his patent above mentioned may show : —

"The first or communicating station produces in its condenser rapid charges and discharges. These add to and take from the line a number of small electric impulses without affecting the mean magnetizing power of the currents through the line; these impulses charge and discharge the second condenser at the other end.

"These undulations in the second condenser can be utilized in the following manner: —

"*First.* If the condenser be made of paper and metal foil, the rapid charges and discharges produce a musical sound.

"*Second.* If those rapid alterations be made to pass round a helix containing an iron rod, a musical sound is produced," etc.

He further describes the construction of the condenser, which is made of alternate sheets of tin foil and thin dry paper, and remarks, "Such a condenser, consisting of from 20 to 50 sheets, will be found to be much agitated and to produce a loud note with 500 alternations of current per second, if the potential be 50 to 100 volts."

Mr. Varley subsequently employed a similar arrangement as a musical telephone, which was publicly exhibited in London, in the summer of 1877. See *Telegraph Journal and Electrical Review,* Vol. 5, 1877, pp. 176, 178.

Similar experiments by MM. Pollard and Garnier are described by Count Du Moncel, in a volume entitled *Le Téléphone,* Paris, 1878, from which the following is extracted (pp. 122, 123): "Si on place dans le circuit induit d'une bobine d'induction reliée à un téléphone, un condensateur de grande surface et que l'on éloigne assez le contact de plombagine de la lame vibrante pour ne la toucher que momentanément à chaque vibration, on ne reçoit plus naturellement les articulations des sons, mais seulement les notes d'un air que l'on chante devant la plaque du transmitteur; seulement le courant inducteur ayant des interruptions brusques, engendre des courants très-intense, et, suivant, MM. Pollard et Garnier, on entend dans tout un appartement l'air chanté, mais avec un timbre particulier qui dépend de la construction du téléphone et du condensateur."

This is translated as follows: "If we insert in the induced [*i. e.,* secondary] circuit of an induction coil connected with a telephone, a condenser of large surface, and withdraw the carbon from the vibrating plate so far that it touches it only momentarily at each vibration, we naturally no longer receive the articulation of the ounds, but simply the notes of an air which is sung before the plates of the transmitter; but as the interruptions of the inducing current are sudden, it produces very intense currents, and, according to MM. Pollard and Garnier, one hears the air which is sung throughout the whole room, but with a peculiar quality which depends upon the construction of the telephone and the condenser."

Previously to 1867, Dr. Wright of Edinburgh showed (*Transactions of the Royal Scottish Society of Arts*, 1860–1864, vol. 6; Appendix, pp. 185–187. *Ferguson on Electricity*, 1867) that a condenser formed of two sheets of paper silvered or covered with thin metal foil placed back to back, or of thin plates of zinc slightly curved and separated by sheets of insulating paper, would produce loud sounds when connected with the secondary wire of an induction coil. These condensers reproduce musical sounds, and both forms are suited to reproduce articulate speech so that it can be readily understood, and will do so, as I know from repeated experiments with condensers of the same construction. Either form inserted in circuit with a Dolbear receiver, or in place of such receiver, with any arrangement of conductors which will produce speech in the latter, will give forth the words spoken into the transmitter with a loud tone and distinct articulation.

In an article in *La Lumière Electrique*, 3me Année, No. 5, March 1, 1880, p. 90, is found a description of certain forms of speaking condenser, which shows that this instrument and its function of reproducing speech were well known at that date, as appears by the following extract: —

"MM. Herz, Dunand et Coulon en ont construit dans des conditions differents et parfaitment isolés. Ils en ont fait avec du papier dioptique, du papier paraffiné, et même en substituant au papier du vernis à la gomme-laque ou du vernis noir qu'on répandait sur chacun des faces des feuilles d'étain et qu'on séparait de plus par du papier, et tous ces condensateurs parlaient fort bien. M. Coulon a demontré d'ailleurs dans un travail très-intérressant sur les condensateurs que nous avons publié dans ce journal (Année 1879) *que les condensateurs dont les feuilles de papier étaient percés de petites trous produits par des étincelles, et qui se trouvaient en conséquence* *mal isolés, devanaient muets*, alors qu'étant percés de trous non carbonisés comme des trous d'aiguille, ils reproduisaient les sons. Toutefois il a reconnu que *c'étaient quand l'isolation était la meilleure possible que la repetition des sous était la plus énergique.*"

This may be translated as follows: "Messrs Herz, Dunand and Coulon have constructed these [i. e., *condensers*] under conditions which were different and perfectly independent. They have made them of transparent paper [*tracing paper?*], of paraffine paper, and even in substituting for paper shellac varnish or black varnish which was spread upon each of the faces of the sheets of tin, which were further separated by paper, and all these conductors produced speech very well. Further, M. Coulon has shown in a very interesting article which we published in this journal (in 1879) that condensers in which the paper sheets had been pierced with small holes produced by sparks, and which consequently were not well insulated, became silent, although when the perforations were small like needle pricks and the paper not carbonized, they reproduced sounds. However, he has always found that it was only when the insulation was as perfect as possible that the reproduction of sounds was most energetic."

A little later, M. Herz applied the speaking condenser in a system of telephony developed by him, and patented in France toward the end of 1879 or early in 1880. In an article upon this system by Du Moncel, *La Lumière Electrique*, Année 3, No. 6, Feb, 5, 1881, p. 100, the author says: "Comme récepteur, on a employé les téléphones magnetiques, mais aussi le *condensateur parlant*, et à ce sujet il ne sera pas sans intérêt de rapporter les différentes expériences qui ont été faites depuis près d'une année avec cet intéressant instrument."

"Le 23 juin, 1880, M. Herz m' ayant prié d'assister aux expériences qu'il faisait boulevard Saint Marcel, attira mon attention sur ce fait qu'un condensateur de petite dimension comme en on trouve chez tous les constructeurs a Paris, pouvait, dans certains conditions, réproduire la parole. Je pus effectivement constater ce fait et je'en fus trés étonné."

Translated, this is as follows: "As receiver the magnetic telephone has been employed, but also the *speaking condenser*, and it will not be without interest in reference to this subject to recall the various experiments which have been made, within a period of nearly a year, with this interesting instrument."

"On the 23d of June, 1880, M. Herz, having requested me to be present at experiments which he was making in the boulevard Saint Marcel, drew my attention to this fact, that a condenser of small size, such as may be obtained from any of the instrument makers in Paris, could, under certain conditions, reproduce speech. I was able actually to confirm this fact, and was greatly astonished at it."

In the same article, Du Moncel further says, p. 101: "Avec ce système on est parvenue, comme nous l'avions annoncé, à entendre la parole, du moins quelques phrases détachés, a une distance énorme, 1,100 kilomètres. On a reconnu qu'avec trois éléments Leclanché on pouvait correspondre aisément sur les lignes de Paris, Tours, Poitiers, etc., même quand les lignes voisines étaient en pleine activité." Again, p. 102: "Le condensateur parlant a pu être très bien entendu entre Paris et Orleans et entre Paris et Tours."

This translated is as follows: "With this system they have succeeded, as we have announced, in understanding speech, at least some detached phrases, at an enormous distance, 1,100 kilometres. It has been found that with three Leclanché elements one could converse easily upon the lines of Paris, Tours, Poitiers, etc., even when the adjoining lines were in full activity." Again, p. 102: "The speaking condenser has been very well understood between Paris and Orleans and between Paris and Tours."

This system was also patented in England in July and August, 1880. See *Telegraphic Journal and Electrical Review*, vol. 10, Oct. 1, 1880, p. 336.

In the volume entitled *The Speaking Telegraph, Talking Phonograph and other Novelties*, by George B. Prescott, New York, 1878, will be found, pp. 231, 232, a description of a form of telephonic apparatus attributed to Edison in which the attraction of a diaphragm by varying charges of statical electricity is employed. Edison uses an electrophorus disk as the source of the charge, which is varied by the to-and-fro motion of a vibrating metal disk placed in front of and very near to it. The receiver is of exactly the same construction, and its operation depends upon the vibratory motion communicated to the diaphragm by the variations of the charge produced by the electrical undulations sent over the line from the transmitter. In his own account, quoted in Mr. Prescott's book, he says of this form of the instrument: "The vibrations of the transmitting diaphragm cause a disturbance of the charge at both ends of the line, and thus give rise to faint sounds. Perfect insulation, however, is necessary, and either apparatus can be used both for transmitting and receiving, but the results are necessarily very weak.

"Another form of electro-static telephone is shown in Fig. 3 (*omitted here*). In this arrangement Deluc piles of some 20,000 disks each are contained in glass tubes A and B, and conveniently mounted on glass, wood or metal stands. The diaphragms, which are in electrical connection with the earth, are also placed opposite to one pole of each of the piles, while the opposite poles are joined together by the line conductor. Any vibration of either diaphragm is thus capable of disturbing the electrical condition of the neighboring disks, the same as in the electrophorus telephones; and consequently the vibrations when produced by the voice in one instrument will give rise to corresponding electrical changes in the other, and thereby reproduce in it what has been spoken into the mouthpiece of the former." So far as the action of the varying electrical charge upon the diaphragm is concerned, this form of telephone is substantially identical with the receiver No. 3 described by Mr. Dolbear in his patent No. 240,578, p. 2, lines 24 to 33, in which, for the metallic back plate, is substituted a plate of hard rubber, which is to be electrified by the friction of a felt pad turned by the hand.

The references and extracts given in the preceding paragraphs clearly show that the production of sound by the charging or discharging of a condenser, or by suddenly reversing the charge, was familiarly known long before the date of Dolbear's patent; that the condenser had been used for the production of musical sound as by Mr. Varley and Dr. Wright as early as 1870 or earlier; that in 1880 it was well known from widely disseminated publications that the condenser could be used as a telephonic receiver for the reproduction of articulate speech; that in the same year a complete telephonic system, that of M. Herz, in which the speaking condenser was an essential part, was made the subject of patents in France and

England, and was proved by successful experiments to be practicable; and further, that as early as 1878, Edison had proposed, and published an account of, a receiver dependent upon the same electrical action, and in principle and mechanical arrangement essentially the same as the Dolbear receiver.

It is asserted by Mr. Dolbear in his affidavit that the action of electricity in producing sound in his receiver is due to electro-static attraction, while in the speaking condenser employed by other experimenters the sound was produced by disruptive charges through the insulating material of the condenser.

The same assertion is also made in the affidavit of Mr. Pope for the defendants. That attraction is a consequence of the charge produced upon the plates of the receiver is unquestionably true; and it is equally true that if these attractions take place in the proper order, they may cause the plates to vibrate in such a manner as to reproduce speech. This attraction will necessarily be produced, however, in any form of condenser composed of metal sheets or plates separated by insulating material, whether the latter be simply air, or consist of solid substances, like paper saturated with shellac, paraffine or the like, when subject to varying charges of electricity; and the attraction of the sheets of metal, if sudden, must caüse not only themselves to vibrate, but also the insulating material itself, in short, the whole mass of the condenser. These vibrations, if sufficiently intense, must give rise to audible sounds. But there is another efficient cause for the sound in the direct action of electricity upon the insulating material of the condenser itself, whether this be air alone or some solid substance. The remark of Sir William Thomson, already quoted, attributes the sound produced in the condenser used in his experiments to the air between the plates. He says: " It is distinctly proved that a plate of air emits a sound on being suddenly subjected to electric force, or on experiencing a sudden charge of electric force through it. This seems a most natural result when viewed in connection with the new theory of Faraday, in his series regarding the part played by air or other dielectric in manifestations of electric force." This language cannot be interpreted as implying that anything in the nature of a disruptive discharge took place; and he expressly states that nothing of the kind occurred.

The production of sound in the charge and discharge of a Leyden battery had previously been observed by Knochenhauer in 1853, (*Pogg. Ann.*, vol. 90, p. 189, 1853), and was explained by De La Rive (*Archiv. Sc. Phys.*, t. 25, p. 64, 1854) as being a consequence of the electric polarization of the glass, in accordance with the theory proposed by Faraday. That the dimensions of glass under the action of electric charges undergo an alteration has long been known, having been observed by the Abbe Fontana in the case of a Leyden jar, more than a century ago. This observation is quoted by Righi in the memoir mentioned below, from a letter of Volta, dated Jan. 27, 1776. In 1878, Duter investigated the character of this change in glass, and concluded that it was due to a specific action of electricity and was not to be explained as the result of an increase of temperature. (*Compt. Rend. de l'Acad. Sc.*, 87, pp. 828, 960, 1036, 1878.) This was confirmed by Righi, *Compt. Rend.*, t. 88, p. 1262, 1879, who further determined the fact that the total dilatation in the case of glass could be considered as made up of two parts, one of which appeared and disappeared instantaneously with the charge and discharge, while the other persisted for some time. He expressly attributed the action of Varley's singing condenser to the effect of these instantaneous changes of volume produced by the sudden electric variations in the insulating material. In an extended memoir, published in 1880, in *Wiedemann's Ann. der. Phys. u Chem.*, Quincke showed that, besides glass, mica, quartz, india-rubber, carbon disulphide, water, alcohol, and a number of other substances exhibited like effects on being subjected to dielectric polarization.

Finally, Lippmann, in a discussion of some experiments made by Boltzmann in 1875, established the fact that air and other gases likewise experience a change of volume on being summitted to dielectric polarization, the change in this case being a contraction. *Journal de Physique*, t. x, No. 117, 1881, pp. 384–389.

The mechanical effect of these changes of volume in the insulating material of the condenser in producing vibration would depend upon the intensity of the charge and the suddeness of its variations. When these are rhythmical or conformed to the undulatory motion produced by articulate speech, it is a natural and necessary consequence that, if sufficiently energetic, they produce musical tones or intelligible speech. In all forms of condenser then the production of sound must involve the operation of both the causes above mentioned, and the preponderance of the one or the other will depend upon the form of the particular instrument employed as a receiver. That it is not due to disruptive discharge is evident from the observations of Sir W. Thomson and Coulon, already quoted. Such a discharge destroys the condenser and incapacitates it for producing sound.

If the space between the plates of a Dolbear receiver be filled with insulating paper or other dielectric material, it will still produce sound and reproduce speech, though somewhat diminished in intensity, since the plates, by being more or less rigidly confined, are placed in conditions less favorable to energetic vibration. The Dolbear receiver in its essentials is simply an air condenser, and owes its power to reproduce speech to the same causes as other speaking condensers.

Whether Mr. Dolbear was the first to apply the particular mechanical arrangement of the condenser described in the specifications of his patent for the purpose of reproducing speech does not seem to me to be material to the inquiry whether the fifth claim of Mr. Bell's patent 174,465 is infringed by Mr. Dolbear. The precise form of structure used by Mr. Dolbear is not fouud in the publications I have mentioned. His work constitutes a variation in the nature of an improvement in a well-known instrument.

ARTHUR W. WRIGHT.

NEW HAVEN COUNTY
STATE OF CONNECTICUT, ss.

FEBRUARY 27, 1882.

Then and there personally appeared Arthur W. Wright, signer of the forgoing affidavit, and made oath that the statements therein contained are true, before me,

[SEAL] CHARLES B. MATTHEWMAN,
Notary Public.

In accordance with the stipulation on file, the complainants introduce as evidence the following from the printed record in the Dowd suit in this court:—

The Varley patent, No. 1044, April, 1870.
Extract from deposition of Prof. Charles R. Cross, as below.
Extract from deposition of Mr. Thomas A. Watson as below.

Extract from Deposition of Prof. C. R. Cross *in* Dowd *Suit.*

Int. 34. What must a speaking telephone accomplish with reference to the form of vibration in order to transmit articulate speech, or to transmit those peculiar qualities which distinguish one sound from another sound, when all are what are called of the same pitch and loudness?

Ans. The transmitter must take up from the air particles motions which correspond to those of the air particles themselves, and the receiver must reproduce these motions in all their complexity.

Int 35. What characteristics must an apparatus possess in order to be able to accomplish this?

Ans. In an electrical speaking telephone, the connection between the transmitter and receiver must be such that the latter shall not be acted upon merely at separate intervals, but the armature or other moving portion of the receiver must be constantly under the influence of and guided by the variations in the electrical current caused by the motions of the armature or other vibrating portion of the transmitter; and this vibrating portion of the transmitter itself must be able to substantially take up the complex motion of the air particles which act upon it. Only in this way can the quality as well as the intensity of vocal or other sounds be reproduced, since not only the frequency of vibration but also the varying amplitude, and especially the varying form, must be reproduced in order to reproduce the quality called "articulation." The electrical current of the instrument must always present an uninterrupted path by which the continual varying current may travel from the transmitter to the receiver; that is, the circuit containing the battery or other source of electrical power, the transmitter, line wire, receiver and earth or return wire must always be closed.

Int. 36. Suppose you work your instruments with an induction coil between the transmitter and the receiver, does that interrupt the connection or path between the transmitter and receiver in the sense in which you have used those terms? If it does not, state why not, and state what conditions must be observed as to the primary and secondary circuit when you so use an induction coil.

Ans. The circuit, under these circumstances, is not broken in the sense in which I have used that term. For successful transmission of speech in those forms of telephonic apparatus in which an induction coil is used, the primary as well as the secondary circuit must be kept uninterrupted. The operation of the induction coil is such that although no current is passed from the battery at the transmitter through the receiver, yet every variation of the primary current is reproduced by the secondary current, so that the receiver is as constantly and fully under the influence of the transmitter as if the primary current itself were transmitted.

Extract from Deposition of T. A. WATSON *in* DOWD *Suit.*

Int. 50. Have you had any practical experience as to the effect of taking away in whole or in part the casing which, in the ordinary hand telephones, encloses the space immediately behind the diaphragm, and round the coil of the magnet? If yea, state what experience you have had on that subject, and what is the result of making that change.

Ans. I have. In the summer of 1877 I had some hand telephones made for practical use, with a portion of this casing removed. About twenty-five of these were sent out to our agents. I received complaints shortly after, that they did not work satisfactory, on account of the holes back of the diaphragm, and that the agents were obliged to stop up the holes in order to make the instruments work successfully. I made a careful test myself, and saw that it would not do to leave the casing open, and had a number of telephones then in process of manufacture altered. In Indianapolis, in June of the present year [1879], I was using a telephone in which our agent had made holes back of the diaphragm. I did not know at first that the holes were there, and was surprised at the difficulty with which I heard the voice of the distant speaker. On examining, I found what the trouble was. On stopping up these holes with my fingers I could hear much better. In my opinion, having the back of the diaphragm open would prevent the telephone from being used in many cases where there are outside noises; and I should consider that if two telephone companies were in competition, one using a closed diaphragm, and the other a diaphragm open at the back, the former company would have a great advantage over the latter company.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR ET AL.

ON MOTION FOR INTERLOCUTORY INJUNCTION.

AFFIDAVITS FOR DEFENDANTS IN REBUTTAL.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY

No. 1628.

American Bell Telephone Company

v.

Amos E. Dolbear et al.

SECOND AFFIDAVIT OF FRANK L. POPE.

Professor Cross in his affidavit in reply describes a number of experiments.

In fig. 1 (which is copied from p. 20 of his affidavit in reply) the arrangement in general use is shown.

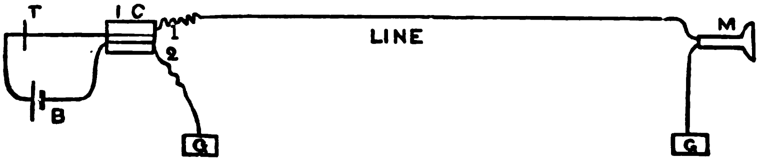

Fig. 1.

This is by far the best arrangement for the practical use of the magneto-receiver, and, in my opinion, is the only arrangement now known of any practical value for using the microphone transmitter with the magneto-receiver.

Two essential features for the proper working of this arrangement are that the secondary coil should be adapted to the line, and that both ends of the line should be grounded, or (what is the same thing electrically) that a ring circuit should be used. As to the coil: the well-known law, followed in practice in all cases as nearly as possible, is that the resistance of the coil — commonly called internal resistance — should equal that of the line including the helix of the receiver, commonly called external resistance, because such a coil with such a line furnishes the maximum current in the line, with a given generating current in the primary circuit. And the grounding or the use of a ring circuit is also essential to the best practical working of this arrangement for the same reason, the current being at its maximum when the proper coil is used with a line properly grounded at both ends, or formed into a ring circuit. Now, as the greatest possible current which can be attained with this arrangement (fig. 1) is considerably less than is necessary for speech that can be heard a yard or more from the receiver (as is well known), it is clear that any serious diminution of this current is hurtful.

April 12, 1882, I tried the arrangement shown in fig. 1 with two coils, one of which was 315 ohms' resistance — the smallest I could obtain at that time — and the other 6170 ohms.

With the smaller coil, which was about six times too large, for the external resistance was not over 50 ohms, the speech was far louder than with the larger coil. I am satisfied, from the perfectly familiar laws governing this matter, that a considerably better result would have been obtained with a coil of 50 ohms than with the 315-ohm coil; and found a very marked difference in loudness between the 315-ohm coil and the 6170-ohm coil, the 315-ohm coil giving far better results than the 6170-ohm coil.

This difference is in accordance with the familiar laws governing this matter, which are so well known that all good workmen set up telephone lines in accordance with them. I will here briefly explain as to this.

The soft iron core in connection with the secondary coil constitutes a magneto-electric generator. Whenever the magnetism of the core is increased by the action of the primary a difference of potential is set up in each convolution of the secondary coil, tending to produce an electric current of a given polarity or direction. When the magnetism of the core is diminished the same effect is produced, but in a reverse direction, tending to produce a current of a polarity opposite to the first one. The strength of current generated by the coil in any particular case is determined by Ohm's law; viz., by dividing the electro-motive force, as measured by the potential, by the resistance of the conductor. If we wish to produce the most powerful effect in a Bell or electro-magnetic receiver it is necessary to produce the strongest possible current; we therefore wind the secondary wire a sufficient number of times around the core in the form of a helix. If we assume as a unit of potential the potential which is set up in a single convolution of the wire, and as a unit of resistance the resistance of a single convolution, we shall obviously increase the electro-motive force and the resistance in equal increments by each added convolution. But inasmuch as all the electro-motive force in the circuit is within the secondary coil, while the resistance is partially within and partially without, including as it does the line wire and the helix of the receiving instrument, it is evident that by this mode of procedure we at first increase the total electro-motive force of the circuit at a more rapid rate than we do the total resistance; and hence we produce an increase in the strength of current in the whole circuit as each convolution is added. The length of the iron core around which the secondary circuit is thus wound is, however, limited by other considerations, inasmuch as a core must be comparatively short in order to be magnetized and demagnetized with sufficient rapidity for telephonic purposes. Hence it is necessary, after having covered the admissible length of the core, to wind another layer of convolutions upon or outside of the first layer. In this second layer the electro-motive force of each convolution is a little less than in the first, because of its greater distance from the core, while its resistance is greater in consequence of its larger diameter and consequent greater length of wire. Thus as we superpose one layer upon another the resistance of the coil increases more and more rapidly in proportion to its electro-motive force, until we ultimately arrive at a point where a current produced by the increased electro-motive force in each convolution is more than counteracted by its increased resistance. This is found to occur when the resistance of the wire of the secondary coil and that of the line are approximately equal, and any increase in the number of convolutions beyond this point results in a decrease of the current. Hence the law of the construction of the Bell secondary for producing the strongest possible current is to maintain the resistance of the coil as low as possible in proportion to its electro-motive force, for the reason that keeping down the resistance increases the strength of current, and a very low potential is of no consequence, provided the strength of the current is adequate.

I also tried the arrangement shown in fig. 4 (copied from p. 23 of Cross' affidavit in reply) with the 6170-ohm coil,

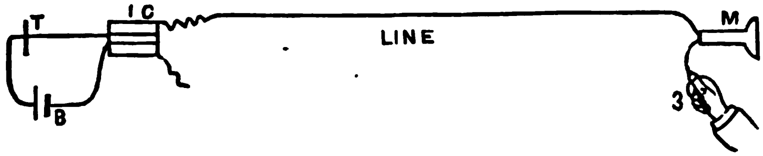

Fig. 4.

and found that the speeech was very faint, but could nevertheless be understood when the room was perfectly free from external sounds. It was not comparable to the speech in fig. 1. I am surprised at the statement of Professor Cross, that "with this arrangement, fig. 4, . . . the transmission was as good as with No. 1." If he means by "transmission" to include loudness or volume of sound, he is certainly wrong. The current in the line in fig. 4 is only a very small fraction of that in fig. 1, and the work it can do is consequently very much less than the work done by the current in fig. 1; and this is mathematically true. The current in fig. 4 is what is known as a current of charge, that is, the line not being grounded or a ring circuit, the current is only that which results from the charging of the line, including the helix of the receiver and the reservoir at the end of the line, — in fig. 4 a human body; and this current is, as I have said, a very small fraction of the current in fig. 1. I did not try the smaller coil with fig. 4, because it was clear to me that the results would have been much less than those obtained from the larger coil, the external resistance being infinite.

I also tried the arrangements shown in figs. 3 and 5 (copied from pp. 22, 23 of Cross' affidavit in reply),

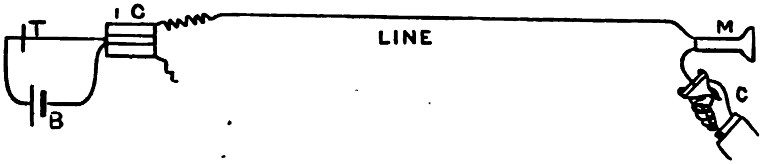

Fig 3.

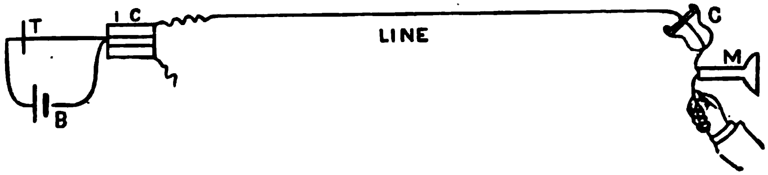

Fig. 5.

and found the results the same in each.

The Bell transmitted speech perhaps somewhat louder than in fig. 4, but far fainter than in fig. 1. There was very little difference between the results from the Bell receiver in figs. 3, 4 and 5; neither of them could be heard except in an absolutely still room; the slightest external noise drowned them. The Dolbear receiver in figs. 3 and 5 gave out very loud and distinct speech. In these trials I used the 6170 ohm coil. The currents in figs. 3, 4 and 5 are currents of charge, and the magneto-receiver is of no practical utility in either of these arrangements.

I also tried the arrangements shown in figs. 6 and 7 (pp. 23, 24, Cross' affidavit in reply),

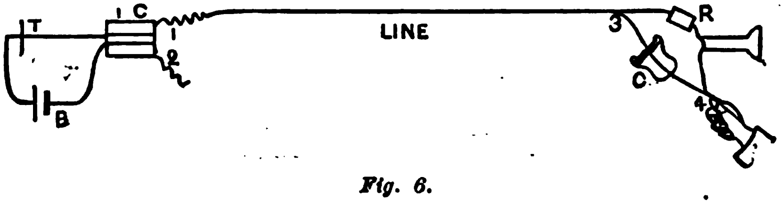

Fig. 6.

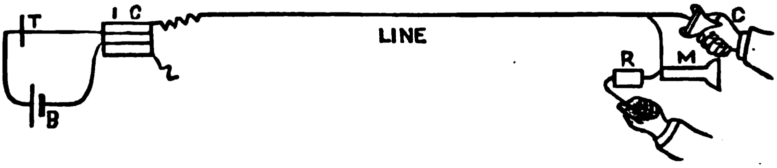

Fig. 7.

using the 6170-ohm coil, and resistances of 12,000, 50,000 and 250,000 ohms; and also without any added resistance. The Bell gave the best results with no added resistance, the same results as in fig. 4, and of no practical value. The results from the Bell differed very slightly until the 250,000 ohms' resistance was used, when the sounds became so faint that although I could hear the sounds I could not distinguish articulation.

When no resistance was added no sound was audible from the Dolbear receiver; when 12,000 was used both receivers were about alike, Bell perhaps slightly better, but both very faint; I concluded that with about 15,000 ohms they would have been about the same, but neither of any practical use. With 50,000 Dolbear good, and with 250,000 Dolbear loud and clear. So far as concerns the Bell receiver, figs. 6 and 7 are substantially the same as figs. 3, 4 and 5; and so far as concerns the Dolbear receiver, figs. 6 and 7, with the high resistance, are substantially the same as fig. 2.

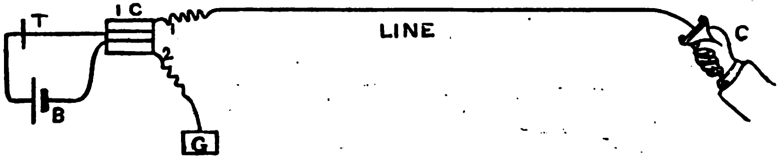

Fig. 2.

I did not try the precise arrangement shown in fig. 8, for the reason that the front plate of Dolbear is described as a part of the line wire, and therefore this arrangement does not differ from fig. 7.

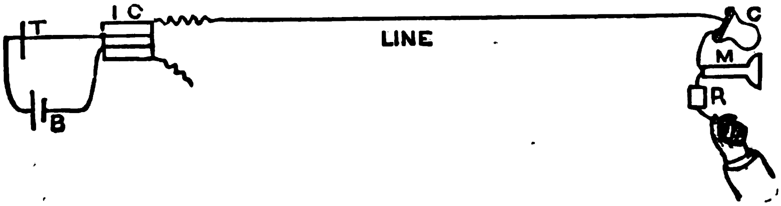

Fig. 8.

I tried the arrangement shown in fig. 9, and found that this gave results much nearer fig. 1 than any of the other arrangements.

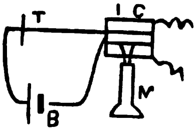

Fig. 9.

Although not so good as fig. 1, this was much better than any of the others. The reason is that this has two reservoirs, each of considerable capacity, with the helix of the receiver forming part of a conductor which connects the two reservoirs. In fig. 1 the two reservoirs are G G, and the generator is I C, while in fig. 9 the two halves of the coil I C are the reservoirs, and also constitute the generator. What happens in fig. 9 is that the electricity in both halves is forced out of one half and into the other, — one half becoming an electric vacuum, the other an electric plenum, — and is compelled, therefore, to flow through the helix between them; the work done depending wholly upon the current from one half of the coil to the other, just as in fig. 1 the work done depends wholly upon the current which flows from G to G.

The fact that it is physically impossible to repeat this experiment (fig. 9) with the Dolbear receiver substituted for the Bell receiver, tends to confirm me in my opinion that the two systems are radically different. Fig. 9*a* shows an arrangement which is as near as

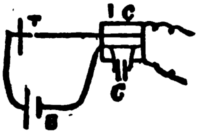

Fig 9. A.

it is physically possible to come with the Dolbear receiver to fig. 9; but this arrangement is radically different from fig. 9, for here there are two distinct secondary coils, instead of two halves of one secondary coil, and each of these two coils is an independent generator, and a generator only, not a reservoir. What happens here is that the electricity in each coil is forced as far as it will go under the stress employed towards one end of that coil; and consequently one of the plates of the Dolbear receiver becomes an electric plenum, the other end of its coil becoming an electric vacuum, while the other plate becomes an electric vacuum, and the other end of its coil an electric plenum.

In fig. 9 one half of the coil is a vacuum when the other half is a plenum, and *vice versa;* while in fig. 9*a* one half of each coil is a vacuum while its other half is a plenum, and *vice versa;* or, in other words, there is but one coil in fig. 9, while there are two coils in fig. 9*a*. Fig. 9 cannot be expected to give so good results as fig. 1, no matter what coil be used, because the current must be less than if the ends of the coil were grounded. In fig. 9*a* the resistance is infinite, and if the number of convolutions in either coil be such as to produce the proper variations of charge in the two plates of the Dolbear receiver, it will work just as well as in any other arrangement.

In my opinion these experiments seem to demonstrate more conclusively the correctness of the statement made in my former affidavit in this case, viz., that the two methods respectively utilize two wholly unlike properties or characteristics of the electrical energy which is manifested in the secondary of the induction coil at the sending station.

The experiments show that the linear conductor may be placed in an electrical condition in which both the properties referred to coexist to a sufficient extent to simultaneously operate the Bell and the Dolbear receivers. Yet it is nevertheless true that just so far as the conditions are changed to favor the working of either receiver, the working of the other receiver is thereby impaired. For example, the organization shown in fig. 1 of Cross' affidavit is that ordinarily employed in the practical operation of the Bell receiver, in which is used an induction coil having secondary of a comparatively small number of convolutions and of low resistance, by which the best results are obtained.

If in this organization a Dolbear receiver be substituted in place of a Bell receiver, no perceptible useful effect is produced therein, as Professor Cross himself states on page 26 of his affidavit in reply.

On the other hand, the organization shown in fig. 2, by which the best results are obtained with the Dolbear method and apparatus, comprises an induction coil having a secondary of many convolutions and of high resistance, which is united to a line disconnected or open at the receiving end. If a Bell receiver is placed in this circuit in the manner shown, for example, in fig. 4, the sounds produced therein are extremely feeble.

Although the secondary of the induction coil employed by Dolbear is apparently substantially the same as that of the coil employed by Bell, the two differing only in respect to the number of convolutions of the secondary around the core and the resistance of the coil, yet in my opinion this statement does not express the real difference between them.

I have already explained the laws in accordance with which the secondary coil used in the Bell system must be constructed to produce the best results, and I will now explain the laws which control the Dolbear system, so far as the secondary coil is concerned.

In the construction of the Dolbear coil the object in view is to produce the highest possible potential, irrespective of the resistance incidentally caused thereby. We therefore use a fine wire enabling a very great number of convolutions to be placed within the necessary space, whereby we get a very high potential, though the resistance of the coil may amount to many thousand ohms.

That the conditions necessary in order to secure the best results by the methods of Bell and Dolbear, respectively, are not the same, but, on the contrary, are to a great extent antagonistic, is well shown by the experiments of Professor Cross illustrated in fig 6, page 28 of his affidavit, in which the line is divided at the receiving station into two branches, one of which is an open and the other a closed branch. The open branch contains the Dolbear receiver, and the closed branch the Bell receiver. An adjustable resistance is interposed in the closed branch, and upon removing this resistance altogether so as to permit a current to flow freely to a reservoir of sufficient capacity the Bell receiver operates as well as it can in an open circuit, while the Dolbear receiver does not operate at all, for the reason that the difference of potential between its plates is practically nothing. As the resistance R is increased the sound in the Dolbear receiver becomes perceptible and continues gradually to increase in loudness, while, on the other hand, that in the Bell receiver gradually decreases. This result necessarily follows, from the fact that the electric potential at the receiving end of the line is gradually increasing as more and more resistance is interposed, while the strength of current at the same point is gradually decreasing. In other words, we are enhancing that property of electricity in the line by virtue of which the Dolbear receiver acts, and suppressing that property by virtue of which the Bell receiver acts. If the resistance be made great enough, the Bell receiver will become quite silent, while the Dolbear receiver will then produce sounds of maximum loudness.

This experiment shows what Professor Cross himself admits (pp. 31, 32), that the electricity in the conductor has two properties, and that if we place the two receivers side by side in the same conductor, one property moves one, and the other property moves the other.

I believe Dolbear to have been the first to discover that one of these properties of electricity (that which he uses) could be made available for the utilization of magnetic variations of the peculiar kind necessary to produce articulate sounds.

Professor Cross refers to certain particular pieces of apparatus in existence prior to the date of Bell's patent, in which he says electrical variations in the secondary circuit of an induction coil were utilized to produce sounds by causing vibratory movements in plates, viz., those of Wright, Varley and Thompson, the construction and operation of each of which he describes at some length. Unless Professor Cross here uses the term " electrical variations " in a wholly different sense from that in which he has used it elsewhere (as, for example, on page 4 of his affidavit in reply), as defining an electrical condition which increases or decreases gradually as distinguished from a condition which passes suddenly from zero to maximum and from maximum to zero, the examples cited, all of which were known to me at the time of making my former affidavit, do not appear to me to sustain his statement, or to refute the statement made by me. In the description of the transmitter of Wright, which was the same as that of Reis, it is distinctly stated by Professor Cross (p. 38) that the primary circuit was made and broken; and the same statement is made with reference to that of Varley. Sir William Thompson also states that his condensor, from which sounds were produced, was charged and discharged suddenly; and Professor Cross says the same thing as to similar experiments of his own (pp. 38, 39). The changes produced in the primary coil in all these cases were not of electrical variations in the sense in which this term is used in the Bell patent.

In speaking of the current in the primary circuit of the Bell and the Dolbear apparatus, Professor Cross himself states (p. 4) that the special form of electrical variations in the primary circuit is the cause of the special form of electrical variations in the secondary circuit. Hence the knowledge of the fact that a sound having a definite pitch, although destitute of quality, could be produced in a condensor connected with the terminals of a secondary coil, by making and breaking a current of uniform strength in the primary coil, cannot have imparted to any one the knowledge that a continuous current of varying strength in a primary circuit would produce sounds in a condenser varying in loudness and quality as well as pitch. It has not yet been shown that any person had this knowledge prior to the discovery of Professor Dolbear, and if such be the case, in my opinion the use of a condenser in this manner is something absolutely unlike, and therefore not an employment of a well-known substitute for, the receiver of Bell.

As I understand the affidavits of the complainants in reply it is sought by means of them to establish two points: first, that the electrical condition in the secondary coil and in the linear conductor, by virtue of which the vibrating plate of the receiver is controlled by that of the transmitter, is essentially the same in Dolbear's method as it is in Bell's; and second, that the receiver of Dolbear, consisting of a resilient plate which is caused to vibrate by varying electrical attraction, is a well-known substitute or equivalent for the receiver of Bell, in which a similar plate is caused to vibrate by varying magnetic attraction.

I have no doubt that the electrical condition in the secondary coil and in the conductor is radically different in the two methods; and I believe Dolbear was the first to discover that the electrical condition used in his method could be used.

Professor Cross states that electrical undulations similar in form to the sound-waves to be transmitted are produced in both apparatuses by the sound-waves at the sending end, and these undulations are in turn the cause of the sound-waves heard at the receiving end. This is unquestionably true, and it is the inevitable physical condition of the use of electricity for the transmission of speech. I understand him to draw from this fact the conclusion that not only Dolbear's method and apparatus, but any method or apparatus whatsoever by which electrical variations of any character similar in form to the sound-waves to which they are due are employed to produce similar sound-waves at another point, is embraced within the scope of the fifth claim of Bell's patent; that is to say, that every such method is of necessity substantially the same as the method described by Bell.

My attention is called to the statement of Professor Cross, on page 12 of his affidavit in reply, that "electrical signals are generally given by electrical variations." This is not so unless the word "variations" be used loosely. All electric signals were given, until within a few years, by the presence or absence of a current, and not by variations of current. It is true that a galvanometer needle would show variations of current which did not succeed each other too rapidly; but no use has ever been made of this for signalling. All signalling instruments known to me before Gray's universal receiver were operated by the presence or absence of given strengths of current, and not by variations of current. And no use whatever was ever made of variations of charge, so far as I know or have any reason to believe, before Dolbear discovered that they could be used.

FRANK L. POPE.

Subscribed and sworn to before me this 29th April, 1882.

[SEAL]

W. C. WITTER,
Notary Public, N. Y. Co.

SECOND AFFIDAVIT OF HENRY C. BUCK.

Henry C. Buck, of lawful age, being duly sworn, says, —

I have already given an affidavit in this case.

I have carefully read the affidavits in reply on behalf of the complainants, and have in connection with Mr. Frank L. Pope repeated the experiments spoken of by Professor Cross.

I first knew of the Dolbear system in 1879, and have repeatedly performed experiments, the same in all material respects as those mentioned by Mr. Cross (except fig. 9), during 1880 and 1881.

On April 12, 1882, I tried two secondary coils, as in fig. 1, one of 315 ohms, the other of 6170 ohms, and have tested many other coils in fig. 1, up to 10,000 ohms. The smaller one was far too large for the best results, and with the larger one the speech was much weaker.

These results are in accordance with familiar laws so well known that no practical workmen would think of using a 315-ohm coil with a line whose resistance was only 50 ohms, and expect to get so good a result as with a 50-ohm coil. A single cell or a single convolution of a secondary coil (both generators of electricity) will give as great a current as can be obtained from any number of like cells or convolutions, if there be no external resistance.

For if you use one generator without external resistance the current you get is volts divided by ohms, say $\frac{1}{1} = 1$, where the numerator represents the electro-motive force, the denominator, the internal resistance, and the quotient, the current. Now two like generators, arranged to double the electro-motive force, will also double the resistance, and will give $\frac{2}{2} = 1$; the quotient being the same as before, because dividend and divisor are both doubled; and so as to any number of generators, each like all the others, so long as there is no resistance except that of the generators themselves, or internal resistance.

But in a secondary coil for use with a telephone the core must be short, and therefore the convolutions of the coil must be in layers; and it is only those convolutions which make up the inner layer which give the maximum current, those of the next layer generating slightly less electro-motive force, and offering a slightly increased internal resistance, and so on; so that a coil with but one layer of convolutions will, if there be no external resistance, give the same current as a single convolution, while a coil of two layers will give slightly less current than a coil with one, and a coil with three, slightly less than one with two, and so on, until you reach a limit where the potential is so high and the resistance so great that it is practically impossible to insulate the convolutions from one another, the current passing through the insulating material in preference to traversing the wire of the coil, because the resistance of that material to its passage is less than the internal resistance of the coil, and the potential is high enough to overcome the resistance of the insulating material.

In fig. 1 the current flows from G to G; that is to say, every increase in the magnetic energy of the core tends to make one end of the coil an electric vacuum, and its other end an electric plenum, and every decrease, *vice versa;* but as the resistance is slight, electricity flows into the vacuum end from one G and out of the plenum end into the other G, the current being the quotient obtained by dividing the potential by the resistance. But it should also be noted that potential depends not only upon the number of cells or convolutions used, but also upon resistance, for with a given quotient and divisor there can be but one dividend. If a generator could be conceived wholly without internal resistance, the electricity generated by it would be without potential; and the largest battery or coil will give no more potential than enough to overcome the total resistance — external and internal. Consequently, if the potential and current be given the resistance follows; if the resistance and current be given the potential follows; and if potential and resistance be given the current follows. This is Ohm's law.

Figs. 2 and 3 show two forms of the Dolbear apparatus, both well known to me. In both the resistance is infinite, and consequently there can be no current except what is known as a charging current, which is that current which is essential in order to redistribute the electricity of an insulated body. Professor Wright says (p. 57) that Ohm's law does not apply to these currents of charge, and also that that law does not apply to the currents in fig. 1. He is certainly wrong in this; every telephone line ever heard of before Dolbear's discovery was subject to Ohm's law. Perhaps Professor Wright may mean nothing more than that Ohm's law does not apply to the modifications of Bell's system shown in figs. 2, 3, 4 and 5 (pp. 60, 61). But he is wrong even in this; all currents, no matter how brief, are subject to Ohm's law; although its application is more readily perceived in the case of what Professor Wright calls "steady currents," it is of course equally applicable to all currents, for a current can only exist when potential causes a flow of electricity in spite of the resistance of a conductor; and currents of charge are just as truly under Ohm's law as any other. The main difference is that currents of charge are simply the flow of electricity from one part of an insulated body to another part of that body, while Professor Wright's "steady currents" are flows of eletricity over a closed circuit.

Take figs. 2 and 3 (pp. 21, 22 complainants' affidavits in reply) for illustration. Here the electricity in the line (from G to C, fig. 2, and the coil I C and line, fig. 3) is redistributed at every charge of the magnetic energy of the core. In one case (say an increase of magnetic energy) it flows as far as it can be forced by that increase of energy towards the terminal C, and C becomes an electric plenum; the electric pressure or potential in C and all the line being that of the plenum end of the coil I C. So long as this flow lasts there is a current of charge over the line. If the primary circuit were an open circuit and then suddenly closed, the current of charge in the secondary would begin as soon as any current passed through the primary, and rapidly rise to its maximum and then rapidly fall to zero; and a reflux current would instantly follow, restoring the equilibrium disturbed by the sudden magnetization of the core, the whole occupying a small fraction of a second. The grounding of the free end of the coil I C, as in fig. 2, only slightly increases this current, and has very little effect upon the potential of the plenum end of the coil. On breaking the primary the sudden demagnetization of the core will cause a current of charge to flow over the line in the opposite direction, rapidly rising to its maximum and then rapidly falling to zero; and a reflux current will instantly follow to restore the equilibrium. The outflow into G, fig. 2, in the latter case, and the inflow from G in the former case, being very much less than it would be if both ends of the coil I C were grounded.

In fig. 2 the variations of magnetic energy in the core conform of course to the variations of current in the primary circuit which cause them, and these variations of magnetic energy cause the potential of the coil and line and front plate of C to vary in like manner; and this varies the attraction between the two plates of C, and gives the front plate the necessary motions to cause air-waves like those which move the diaphragm of the transmitter, provided the potential be very high. The same statements are true of fig. 3. I have no doubt that these variations of high potential like in form to the sound-waves (by which they are indirectly produced) are wholly new with Professor Dolbear, and that their precise action cannot be determined by reasoning from anything now known, but can only be ascertained by repeated and excessively delicate experiments.

In the Dolbear system a very great number of convolutions are necessary in the secondary coil, a very high potential being essential. Consequently the two controlling elements in setting up a Bell line, a proper coil, with its internal resistance equalling the external resistance of the line, and proper grounds or a ring circuit (without both of which no practical Bell line can be constructed), are both wholly disregarded in the Dolbear system.

In fact, the generation of Dolbear's variations of high potential is incompatible with the generation of Bell's variations of current strength; and both instruments cannot be made to do good work in the same line, for the reason that the nearer right the line is for one, the worse it is for the other.

I have read Mr. Pope's affidavit in rebuttal, and fully corroborate all he says about the experiments shown in figs. 1 to 9, both inclusive, pages 21 to 25 complainants' affidavits in reply; and also about fig. 9*a*.

I have frequently tried the experiments fig. 11 (p. 26 complainants' affidavits in reply), and have never had the least difficulty in getting perfect speech from the Dolbear receiver with 1,000,000 ohms' resistance in the line, as described by Mr. Cross. I have never been able to get speech from the usual magneto-receiver with anything like 1,000,000 ohms in the line, as in fig. 11. I can get excellent speech with the Dolbear, with 1,000,000 ohms' resistance in the line, with a coil of not over 3000 ohms.

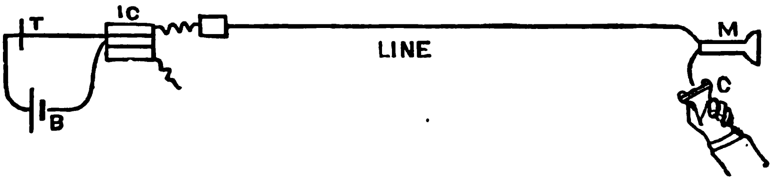

Fig. 11.

The conclusions drawn by Professor Cross from this experiment seem to me radically wrong in one particular, for the resistance interposed between the end of the secondary and its terminal certainly would (and the experiment shows that it did) tend to "prevent the transmission of 'electric pressure,'" just as a very small pipe between a cylinder and a small vessel would prevent a sufficient flow of water into the small vessel from the cylinder, if its piston were forced down even with an enormous force but for a very short time; whereas if the pipe were larger, the pressure in the small vessel would instantly equal that in the cylinder. In both cases there is pressure — water pressure in one, electric pressure in the other; in both cases this pressure is to be exerted at a distant point; in both cases the fluid under pressure must flow to that point and fill up a small vessel there, the pressure in that small vessel being what does the work; in both cases the time is short during which the pressure is exerted on the fluid in the larger vessel, — the cylinder in one case, the coil in the other; and consequently in both cases if the flow be obstructed it will take a longer time to fill the small vessel.

For the proper working of the Dolbear receiver the plate connected with the coil should vary its potential instantaneously with the varying of the coil; and that is what happens unless there be an obstruction interposed between them. The resistance in fig. 11 is such an obstruction, and may be likened to an excessively small pipe preventing the flow of water from a large vessel to a smaller one and back again.

On page 28 Mr. Cross says that "the experiments Nos. 6, 7 and 8 show that leakage, due to imperfect insulation, also affects the [Dolbear] apparatus seriously." This is a mistake, as the apparatus is not appreciably affected by leakage, the "insulation resistance" of any line, fairly well constructed, being ample under the most unfavorable conditions. The results have been found excellent between Boston and New York with the Dolbear apparatus, both in dry and wet weather. As to "insulation resistance," theoretically it is more difficult, somewhat, to insulate the Dolbear line than the Bell; but the ordinary insulation resistance is abundant for the Dolbear line.

The best line for the Dolbear system is a fine wire, with as little superficial area as is consistent with durability, for the reason that Dolbear utilizes variations of charge, and the great resistance of such a line is unimportant in his system; and this is as unfavorable a line for the Bell system as can be imagined, because of its high resistance.

Until after Professor Dolbear's discovery I never knew or heard of any Bell apparatus, except with a closed circuit; and it was Professor Dolbear's discovery that led me to try the Bell apparatus without a closed circuit. Before Professor Dolbear's discovery the only electric variations which were known as capable of use in the transmission of speech were of low electro-motive force, namely, that suited to the low resistance in the line, and did their work by flowing through a helix to ground. The diagram annexed, fig. B, fairly represents these variations, the lower line indicating zero of potential and the second line the potential of the Bell currents; and these currents each varied in potential from maximum at the end of the coil to zero at ground.

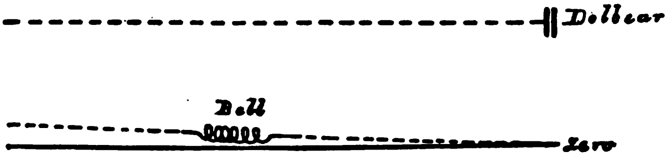

Fig. B

Dolbear's variations are represented in fig. B by the upper dotted line, but not quite fairly, as the distance from the base line should be multiplied many times, if the distance of the Bell line above the base line be taken as representing the electro-motive force of the Bell variations. The Dolbear line should be in such a diagram at least thirty times farther from the base line than the Bell line is.

Fig. B fails to represent another vital difference between the variations used in the two systems. That difference is based upon the well-known fact that if magnetic energy be converted into electric energy, it may be converted into electric energy in which the dynamic property greatly exceeds the static, as in the galvanic current, or into electric energy in which the static property greatly exceeds the dynamic, as in lightning. A given magnetic energy can be converted into only a certain amount of electric energy; but with one apparatus for converting it—an induction coil of say 500 convolutions — the dynamic can be made to greatly exceed the static, while with another apparatus for converting it — an induction coil of say 20,000 convolutions — the static can be made to greatly exceed the dynamic. But the dynamic cannot be increased, except at the expense of the static, and the static cannot be increased, except at the expense of the dynamic; for the electric energy is the sum of the two, and cannot exist in the absence of either. In a stroke of lightning the dynamic is at its minimum, while the static is at its maximum; in a current from one large cell the dynamic is at its maximum, and the static at its minimum. Bell's system utilizes the dynamic, and it is physically impossible to operate the Bell apparatus with the static; and in the best electric energy for the Bell the dynamic must far surpass the static. Dolbear's system utilizes the static, and it is physically impossible to operate the Dolbear apparatus with the dynamic. In the best electric energy for Dolbear the static must far surpass the dynamic.

HENRY C. BUCK.

UNITED STATES OF AMERICA,
DISTRICT OF MASSACHUSETTS,
SUFFOLK, ss. BOSTON, April 29, 1882.

Then personally appeared the above-named Henry C. Buck, and made oath that the foregoing affidavit, subscribed by him, is true.

Before me,

[SEAL] WILLIAM A. COPELAND,
Notary Public.

[*From pp.* 399, 400 *of the Record, Bell Telephone Company et al.* v. *Peter A. Dowd.*]

DEPOSITION OF CHARLES R. CROSS.

Int. 34. What must a speaking telephone accomplish with reference to the form of vibration in order to transmit articulate speech, or to transmit those peculiar qualities which distinguish one sound from another sound, when all are what are called of the same pitch and loudness?

Ans. The transmitter must take up from the air-particles motions which correspond to those of the air-particles themselves, and the receiver must reproduce these motions in all their complexity.

Int. 35. What characteristics must an apparatus possess in order to be able to accomplish this?

Ans. In an electrical speaking telephone the connection between the transmitter and receiver must be such that the latter shall not be acted upon merely at separate intervals, but the armature or other moving portion of the receiver must be constantly under the influence of and guided by the variations in the electrical current caused by the motions of the armature or other vibrating portion of the transmitter; and this vibrating portion of the transmitter itself must be able to substantially take up the complex motions of the air-particles which act upon it. Only in this way can the quality, as well as the intensity or other sounds, be reproduced, since not only the frequency of vibration but also the varying amplitude, and especially the varying form, must be reproduced in order to reproduce the quality called "articulation." The electrical circuit of the instrument must always present an uninterrupted path by which the continually varying current may travel from the transmitter to the receiver, that is, the circuit containing the battery or other source of electrical power, the transmitter, line wire, receiver and earth or return wire must always be closed.

[*From pp.* 221–231 *of the Record, Bell Telephone Company et al.* v. *Dowd.*]

DEPOSITION OF EDWARD S. RENWICK.

Int. 32. I call your attention now to the sixth claim of the second Bell patent, namely, "The combination, with an electric telephone such as described, of a sounding box, substantially as herein shown and set forth." Mr. H. B. Renwick, at the foot of page 23 of the printed record, says of this cover or sounding box that it "encloses that end of the diaphragm which is farthest from the speaker at one end, or the hearer at the other, and thus prevents vibrations of the air, due to noises in the room or other causes, from affecting the vibration of the diaphragm." If there is any practical liability to undersigned vibrations of the diaphragm when it is not enclosed, is it liable to such vibrations to be produced from the side of the diaphragm which is nearest to the speaker at one end, or the hearer at the other, as well as on the side which is farthest from him? And if yea, explain why.

Ans. The diaphragm is liable to be influenced quite as much by undersigned vibrations or extraneous noises made at the side which is nearest to the speaker or to the hearer, as it is at the opposite or rear side. Because the speaking-tube E separates the speaker or hearer from the diaphragm, so that if the diaphragm is not protected at its face side by a cover, extraneous noises would pass to it all around the end of the speaking-tube nearest the diaphragm, which end is less in diameter than the coil of wire G at the back of the diaphragm, and therefore would protect the diaphragm or plate from noises in front to a less extent than the intervention of the coil of wire G would protect it from noises in the rear of the plate or diaphragm.

Int. 33. If there is any practical liability to extraneous vibrations of the diaphragm, such as Mr. H. B. Renwick says the sounding box in the Bell patent protects the diaphragm from on the side farthest from the speaker or hearer, what is it in the said patent which protects the diaphragm from such extraneous vibrations on the other side?

Ans. It is the square piece of wood which, in the telephone represented at figs. 1, 2 and 3 of the said Bell patent, covers the front or face of the diaphragm, and is perforated only by a hole in which the end of the speaking-tube E is inserted. This front board covers the front of the diaphragm, and protects it from all noises or vibrations in front, except the sounds which are purposely applied through the speaking-tube E.

Int. 34. Assuming for the present that there is practical advantage in covering the diaphragm with a so-called sounding box which protects it from extraneous vibrations, will you state whether you find, in any of the instruments testified as used by Mr. Gray prior to the Bell patent, the combination with an electric telephone (having an electro-magnet and a plate of inductive metal or its equivalent as mentioned in Bell's third claim) of a sounding box which protects the diaphragm or its equivalent from such supposed extraneous vibrations? And if so, specify the instrument, and explain its similarity in this respect to the Bell arrangement.

Ans. If the covering with the so-called sounding box includes the covering of the rear side only of the diaphragm or plate, then I find that substantially the same covering or box is found in the " Defendant's Exhibit Diaphragm Box Magnet Receiver." This instrument contains an electric telephone such as is described in the said Bell patent No. 186,787; that is, an electric telephone composed essentially of an electro-magnet and a plate of iron supported in front of the said electro-magnet at a short distance from the poles or core thereof, the magnet within the box being such electro-magnet, and the perforated head of tin-plate or tinned iron being the plate of iron capable of inductive action.

The covering in this defendant's exhibit is formed by the cylindrical wall of the box and the wooden head thereof, which protect the rear side or back of the induction plate from noises or vibrations which are produced at that side of the instrument.

The said Bell patent, as before stated by me, contains the statement that "in lieu of plate A" (the induction plate) "in above figures" (which are all the figures represented in the drawings of the patent), "iron or steel reeds of definite pitch may be placed in front of the electro-magnet O . . . ," which statement, as previously explained by me under division fifth of my answer to interrogatory 30, amounts in substance to a statement that the patentee considers two or more steel reeds, when placed in front of one electro-magnet, as a substitute or equivalent for the induction plate A; and therefore, as I understand the patent, this substitute is included by the language of the claims. Therefore I am of opinion that the "Defendant's Exhibit Gray's Two-octave Transmitter" contains in substance the combination with an electric telephone (having an electro-magnet and the substitute or equivalent mentioned in Bell's patent for a plate of induction metal) of a sounding box which protects the equivalent or substitute for the diaphragm from the supposed extraneous vibrations mentioned in the question. In the case of this defendant's exhibit, each of the electro-magnets corresponds with that required by the said claim; and each set of two or three steel reeds of definite pitch, which are placed in front of one of those electro-magnets, corresponds with the substitute or equivalent for the induction plate A mentioned in the sentence of the said Bell patent above referred to by me. In this defendant's exhibit, also, there is a cover or sounding box, which covers each electro-magnet and each set of reeds, which is combined with one electro-magnet, and protects these reeds (which, according to the said sentence of the Bell patent, are a substitute for the induction plate) from the action of extraneous vibrations. When the cover is closed, these Bell substitutes or equivalents for the induction plate are protected from such extraneous vibrations both in front and rear. When the cover is raised so as to be upright, it protects the said Bell substitutes for the induction plate from extraneous vibrations made at their rear.

Int. 35. Do you believe that there exists in practice any such liability as Mr. H. B. Renwick says the sounding box in the Bell patent provides for, namely, liability of the diaphragm, either at the end farthest from the speaker or hearer, or at the end nearest to him, to have its designed vibrations affected by undesigned or extraneous vibrations, "due to noises in the room or other causes"; and will you describe any practical observations you have made for the purpose of testing your judgment upon this matter?

Ans. I do not believe that in practice any such liability exists. I have experimented with two forms of Bell telephone, which I was informed were manufactured by the Bell Telephone Company, such experiments being made by me in company with Mr. William M. Goodridge and Frank L. Pope. The experiments were made in a noisy locality, the instruments being tested with and without the covers, and both as transmitters and receivers. With one form of instrument I could not distinguish any difference in either the distinctness or loudness of the sounds transmitted or received, whether the cover was on the instrument or removed from it. With the other form of instrument I could not distinguish any difference whatever in any trial but one, in which both the mouthpiece and cover, or plate in front of the metallic plate, were removed, as well as the entire covering in the rear of it. With the instrument in this condition, and used as a receiver, the articulation was materially more distinct without any cover in the rear of the metallic plate than when the cover at that side was in place.

Int. 36. Coming now to the seventh claim of the second Bell patent, namely, "In combination with an electric telephone, as herein described, the employment of a speaking or hearing tube for conveying sounds to or from the telephone, substantially as set forth"; this speaking-tube, which is marked E in the patent, Mr. H. B. Renwick says, in his opinion, "really means the tubular orifice through which the sound-waves are sent, in connection with the chamber at the end of that orifice where the sound-waves act upon the diaphragm." State whether you think that the speaking-tube E really includes the chamber, being, as I understand it, the space between the front face of the diaphragm and what you have spoken of as a part of the sounding box or cover, within which space the vibrations of the diaphragm take place.

Ans. In my opinion the speaking-tube E mentioned in the patent does not include the chamber referred to, because the chamber is not what would be commonly called or understood as any part of a tube, and because there is no statement or suggestion in the patent that the speaking-tube mentioned includes the square piece of board into which its end is inserted, and whose inner side forms a shallow square chamber in front of the plate or diaphragm. Thus, the only language that I have found in the patent in relation to the speaking-tube are the following sentences: "E represents a speaking-tube by which sounds may be conveyed to or from the plate A"; "for convenience of operation through the speaking-tube E"; "to listen to his telephone preferably through the speaking-tube E"; "to convey an articulate message it is only necessary for an operator to speak in the neighborhood of his telephone, preferably through the tube E"; lastly, the words in the claim, "the employment of a speaking or hearing tube for conveying sounds to or from the telephone." The drawings show the letter E placed upon the tube only; and, in the absence of any special description to the contrary, I understand the speaking-tube referred to is that tube, and does not comprehend the plate or board to which it is attached, which, so far as the tube is concerned, is simply a means for holding it in place, and might, according to my understanding, be replaced by any other suitable device for that purpose without changing substantially the character of the speaking-tube described, or its combination with the telephone. If, for example, the said plate or board should be removed, and a narrow bridge straddling the plate, or a single arm projecting from one side of the plate A to the end of the speaking-tube, should be employed in the telephone represented at figs. 1, 2 and 3, the combination recited in the said seventh claim would, in my opinion, exist as certainly as it does in the instrument constructed with a square plate or board; yet, in the case of each of said substitutions there would be no enclosed chamber at the front side or face of the induction plate or diaphragm A.

Int. 37. Assuming that the chamber forms no part of the speaking-tube, will you refer to the Bell patent of 1876, and say whether you find there substantially the same speaking-tube to speak through or listen through, in combination with a diaphragm, towards which vibrations produced by vocal sounds are directed, or from which they are received?

Ans. Whether I do or do not depends upon how much or how little is understood to be comprehended by the term "speaking-tube." If, for example, the term "speaking-tube" is understood to comprehend what is commonly termed a mouthpiece, by means of which sounds spoken into it are prevented from spreading laterally and are thus concentrated, then I find that the transmitting instrument represented at fig. 7 of the Bell patent of March, 1876, has in the cone A (which, as stated in the said patent, "is used to converge sound-vibrations upon the membrane") substantially such a speaking-tube. And in like manner I find that the cone L of the receiving instrument of the said Bell patent of 1876 is such a tube for listening. If, on the other hand, the term "speaking-tube" be employed in the ordinary acceptation in which it is generally used, that is, to denote a pipe of considerable length in proportion to its diameter, for the purpose of conveying sound, then I should be of opinion that a mere mouthpiece or earpiece such as are represented at fig. 7 of the Bell patent of 1876 would not amount in substance to such a speaking-tube.

Int. 38. Will you refer now to the description and drawing of the Reis telephone on pages 257 and 258 of Ferguson's "Electricity," and state whether you find there a speaking-tube, and whether with or without a chamber, for the purpose of conveying vocal sound to a diaphragm for the purpose of the electrical transmision of such sound, the tube or tube and chamber performing the same office, with reference to that diaphragm, as is done in the case of the Bell patent of 1877? And state, in connection with your answer, whether or not, and why, you agree with Mr. H. B. Renwick where he says, beginning at foot of page 46 of the record, "The box of Reis is so great in capacity, and extends so far downwards below the diaphragm, that it will not act practically to concentrate the effect of the air-undulations upon the face of the diaphragm," &c.

Ans. I find in the said Reis telephone, described in Ferguson's work, a speaking-tube, namely, the short, straight, cylindrical tube between the mouthpiece M and the wooden box A. I also find that in said Reis telephone the said speaking-tube is used in connection with a chamber for the purpose mentioned in the question, such chamber being the interior of the box A, and the diaphragm being the piece of the bladder S, which closes the large hole at the top of the said chamber.

I do not agree with the opinion expressed by Mr. H. B. Renwick, as stated in the question, for the following reasons: The drawing shows that the speaking-tube, extending from the mouthpiece M to the box A forming the chamber, inclines downward or in a direction away from the said diaphragm; consequently, the tube directs the sound-waves away from the diaphragm. If, under such circumstances, the sides and bottom of the chamber should be removed and a skeleton support for the diaphragm should be substituted in their place, the sound-waves would be permitted to escape laterally and downward, and a large portion of their force would not act upon the diaphragm. Whereas, when the sides and bottom of the box or chamber A are in place, as represented in the drawing of the Reis telephone, the sound-waves are confined, and must of necessity operate with greater force upon the stretched membrane or diaphragm than they would if the sides and bottom of the box were removed.

Int. 39. Mr. H. B. Renwick says, at the top of page 26 of the printed record, with reference to the speaking-tube E, that the chamber in front of the diaphragm "is absolutely essential in order that the tubular part of the contrivance may convey the sound-waves to the diaphragm." What is your opinion as to the importance of the chamber, or as to the importance of the mouthpiece, as to the matter of distinct and loud speaking or hearing; and what, if any, experiments have you tried bearing upon this question, and with what results?

Ans. Some of the experiments before referred to by me in my answer to question 35 were made with the mouthpiece and front of the box in their places, so that whatever chamber was formed by the front of the box existed in the instrument. Others of the experiments were made with the same instrument, with the mouthpiece removed, and so much of the front of the box as covered with the metallic plate also removed; so that no enclosed chamber existed in front of the metallic plate. I was not able to perceive any difference either in the distinctness of articulation or the loudness of the tone, either transmitted or received, when the instrument was in two different conditions, from which I infer that neither the mouthpiece nor the chamber in front are essential. If a tubular mouthpiece with a speaking-tube be used in order to convey sounds from a distance to the metallic plate or diaphragm, then some device must, of course, be employed to hold the end of the speaking-tube to the diaphragm or plate; but in my opinion a chamber in front of the diaphragm is not essential for this purpose, and a narrow bridge straddling the diaphragm, or an arm for the purpose of holding the end of the tube, would, in my opinion, answer all practical purposes.

Int. 40. You spoke of the room where these experiments and the other experiments mentioned to-day were tried as a noisy room. Please tell us something more about it, tending to show whether it was or was not a room the conditions of which would furnish a severe test of the telephone apparatus used there.

Ans. The transmitting and receiving instruments were in two rooms of the shop of the Western Electric Manufacturing Company on New Church Street in this city, close to the lowest station of the Metropolitan Elevated Railroad Company, where trains are continually arriving and departing, and where, consequently, there is not only the rumble of the trains in motion, but the noise of escaping steam from the locomotives and of the compressed air from the air brakes is heard almost continuously, in addition to the noise of the carts on the street.

Int. 41. What do you think is the use of the chamber in front of the diaphragm in the Bell patent of 1877, and also in the defendant's telephones?

Ans. The chamber itself, so far as my experiments inform me, or my judgment, is of no practical value for the purpose of confining the sound. The plate which forms the chamber serves as a holder for the end of the tube, and for this purpose might be replaced by any kind of a skeleton device, such as an arm, bridge or spider, which would hold the tube in place. The said plate also acts as a cover to keep out dust, and when used for this purpose, it should not bear upon the diaphragm, so that a slight chamber or space between the cover when used and the front of the diaphragm is required to prevent the contact of the cover with the diaphragm.

Int. 42. Have you made any experimental use of any of the common receivers testified as used by Mr. Gray in 1874 or 1875, showing whether, either for the purpose of talking or listening, the diaphragm by itself, without either chamber or speaking-tube, is satisfactory and sufficient?

Ans. In conjunction with Mr. William M. Goodridge, I made a number of experiments with the following common receivers, testified as used by Mr. Gray at the date mentioned, namely, "Defendant's Exhibit Gray's Resonant Box Magnet Receiver," "Defendant's Exhibit Diaphragm Box Magnet Receiver," "Defendant's Exhibit Gray's Concave Metallic Diaphragm Magnet Receiver," each of the said exhibits being used to receive musical tones from vibrating reed transmitters, and to receive articulate speech in connection with an Edison carbon transmitter at the transmitting end of the line. In all of the said experiments the exhibits were used for the purpose of listening or as receivers, and in some of the experiments plain discs of sheet-metal were employed in connection with the magnet, such discs being similar to the solid head of the tin box of "Defendant's Exhibit Gray's Resonant Box Magnet Receiver," without either the cylindrical wall or the perforated cover of the box. The experiments showed me that the plain disc by itself, without either chamber or speaking-tube, is, when used in connection with an electro-magnet, satisfactory and sufficient to enable either musical tones of different pitches or speech to be made distinctly audible to the listener.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR ET AL.

BRIEF FOR COMPLAINANTS ON MOTION FOR PRELIMINARY INJUNCTION.

CHAUNCEY SMITH,
JAMES J. STORROW,
for Complainants.

BOSTON:
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1882

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Circuit Court of the United States,

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BRIEF FOR COMPLAINANTS ON MOTION FOR PRELIMINARY INJUNCTION.

Summary.

Mr. Bell was the first who discovered how to transmit speech by electricity. He accomplished this wholly novel result by employing a method and a mode of operation unknown before. Signals had theretofore been transmitted by causing at one end of a conductor electrical disturbances which passed to and were utilized at the other; but he, by the action of the spoken word itself, caused the successive electrical conditions of the apparatus to assume a new relation between themselves; and this novel relation of each to the other, and consequent novelty in the character of the series, enabled him to produce a new kind of signal which became sensible as articulate speech. He provided an apparatus which enabled the voice to produce this peculiar relation of successive disturbances at one end, and which converted them into sound at the other end of the intervening conductor.

In respect to that most remarkable, novel and characteristic feature of Mr. Bell's invention, the agency of sound waves themselves in modifying the electricity employed to that peculiar character of variation, which enables it to reproduce at one end the sounds uttered at the other, the apparatus of Dolbear is precisely like that of Bell.

The novelty and the operative character of Mr. Bell's novelty did not consist in a special electrical condition at one instant, nor in the amount of electricity employed at any single instant, but in this, that the force or the quantity of electricity present and operative at one instant (whatever it might be absolutely) bore to that present and operative at every other instant that precise and novel relation expressed in his fifth claim; and further, in this, that it was the voice itself which established and controlled this relation. In his claim he expressed this new relation of successive disturbances, and asserted it to be the efficient cause in the electrical transmission of speech.

The defendants transmit speech by employing a succession of electrical disturbances, each of which bears to all the others this new relation. It is the new relation of them in the defendants' apparatus which enables it to transmit speech; and the action of the speaker's voice produces them in their apparatus. Whatever differences exist, it is still true that they transmit speech by using that which was novel with Mr. Bell, which is, and which in his summing up or claim, was named as the characteristic and operative feature of his invention. They therefore use his invention and infringe his patent.

The changes they do make are of a very limited kind. Mr. Bell's apparatus consists of a transmitter, a receiver and electrical conductors to connect them; and the performance of a specific subordinate function by each of these constituent parts is what enables the apparatus as a whole to set up and to produce speech by means of the novelty we have described. The defendants' claim is that they have removed Mr. Bell's form of receiver and replaced it by another which performs the same office as the part it replaces. This does not do away with the necessity for, but on the contrary depends for its result entirely upon the fact that the successive electrical disturbances which act upon it are caused by the voice and bear to each other the precise relation first conceived by Mr. Bell and expressed in his claim.

Their alteration is indeed narrower than this: they have changed merely one part of this subordinate instrument by employing, as the source of the motion of its diaphragm, one known property by which electricity can cause attraction and motion instead of another known property by which it can cause attraction and motion.

Finally, the particular kind of instrument used by them (a condenser receiver) was at the date of Mr. Bell's patent known as a means for converting electrical changes into sounds, and known as a substitute for the kind of receiver (magneto receiver) used by Mr. Bell. Mr. Bell modified the magneto to make it more sensitive and efficient, and the defendants have modified the condenser to make it more sensitive and efficient; but the old forms of acoustic condenser receivers, when the electrical disturbances to which they are subjected are forced to follow the rule of relation laid down in Mr. Bell's claim, will give forth articulate speech with practical efficiency.

The defendants therefore use Mr. Bell's method and Mr. Bell's apparatus. The changes they have introduced are in the nature of improvements upon it (if of any practical utility) and not exclusions of it.

Mr. Bell's claim is not broader than his invention. He controlled electricity by the voice, and thereby modified it to conform to a new rule. That was his method; his claim both asserts it and defines it, by expressing as the substance of it that which was the substance of the invention and novelty embodied in and which gave its particular effect to the specific form of mechanism he described.

CLAIM. 5. — "The method of and apparatus for transmitting vocal or other sounds telgraphically, as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds substantially as set forth."

THE COMPLAINANTS' CASE.

The Subject Matter.

The electric speaking telephone in its normal and typical form is an apparatus consisting of three parts: a transmitting instrument at the sending station, a receiving or reproducing instrument at the receiving or listening station, and a line wire composed of such material and so arranged as to establish an electrical connection between the two. The transmitter contains a plate so elastic and sensitive that the air particles vibrated by the voice will cause it to take up and copy their peculiar motions. The receiver or reproducer contains an extended surface, usually also an elastic plate or diaphragm, which can be thrown into sonorous vibrations by the operation of the apparatus, and which will impart those vibrations to the air at the listening station. The listener there will then hear a sound, the character of which will be due to, and therefore be the same as, the character of the vibratory movements performed by the transmitting diaphragm. The link which connects the two, and thus completes the apparatus as a whole, consists of a line wire by means of whose electrical conductivity every electrical disturbance or series of disturbances produced by the transmitter at one end swiftly cause a like disturbance or series of disturbances at the other.

That electrical disturbances produced at one end of a conductor or series of conductors are also manifested at the other has long been the basis of all contrivances for producing signals at a distance by means of electricity. The following diagram of the main line parts of a Morse telegraph shows one of the oldest forms of such an apparatus.

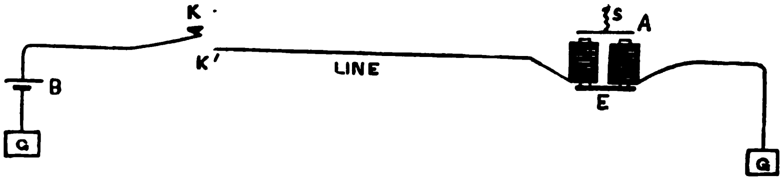


FIG. 15.

Whenever the key K is depressed so as to make contact with its anvil K′, the energy or electro-motive force of the battery B is brought to bear upon the conductor of which K′ forms one end; when the key K is raised that force is shut off. This disturbance or series of electrical changes is propagated as a series of electrical impulses to the receiving end. The electrical changes there produced alternately magnetize and allow to become demagnetized the soft-iron core of the electro-magnet E, whereby the soft-iron armature A, normally kept away from the magnet by the retractile spring S, is alternately drawn to the magnet and allowed to fly back. As often, therefore, as K moves, A moves; and the length of the time during which A is held down or allowed to stay up depends upon the length of the time during which K is kept down on K′ or held up from it.

In order that an electrical apparatus may transmit intelligence, it is obviously essential that the signals produced at the receiving end shall be so far within the control of the sending operator that he can cause at will whichever he pleases among those which the instrument is intended to produce. If the signals depend merely upon the rapidity with which the motions succeed each other, a method capable of controlling that feature will suffice. If the signals are to depend upon other distinctions, then there must be some method by which the sender can control the receiver in respect of, or can produce therein changes in, those other particulars which are to distinguish one signal from another. Frequency, or the rate and measure in which successive instants of action or repose succeeded each other, was all that was needed or employed in the kinds of apparatus known before Mr. Bell.

Mr. Bell, however, proposed to produce a new kind of signal; to wit, one which should appeal to the ear as articulate speech. To that end what was needed was, not that any old apparatus should be improved, but that an entire new departure should be taken; that a new and unheard-of idea and mode of operation should be introduced.

Nature of Articulate Sounds.

To appreciate this novelty, it is needful to realize what constitutes articulate sounds and what enables the ear to distinguish one from another.

The sensation of sound is due to the vibrations of the air particles, and, therefore, each sound has its own peculiar and distinguishable air vibration. The vocal organs push and pull the particle next them; this pushes and pulls the one next in front of it and so on. This disturbance is propagated in straight lines radiating from the source of sound. Moreover, by reason of their inertia and elasticity, motion is not imparted instantly from one to the next, but the second lags behind a little in time, and so with each, as it is in its turn pushed or pulled alternately to and fro; hence the particles are alternately huddled together or more widely separated, and thus at each spot the air is alternately condensed or rarefied. But as each receives its motion from its neighbor, the *character* of the motion is the same for all of them, and thus the particle whose blows fall on the drum of the ear has the same peculiar air vibration that was given to the first of the series by the speaker. If it were not so, the listener would not distinguish the word which the speaker uttered.

The air particle does not travel from the speaker to the listener. It has an oscillatory motion, the total limits of which, in ordinary conversation, do not exceed one thousandth of an inch, and are perhaps far less. What happens is that each particle moves over this small path, and every difference in the whole commotion is due to or more correctly consists in differences between the vibratory movement of the particle at one instant and its vibratory movement at the next. It presents the case of a true wave motion or undulation, which is not the flow of a current, but is a small, oscillating movement at each part, with such connection that, one part moving the next, a " state of displacement " or impulse travels or is propagated onward.

Considering now the vibratory motion of a single particle (to the study of which we may confine ourselves since all possess the same character of motion), it is clear that this, although always limited to a to-and-fro motion over a straight line, may yet vary in several ways. It may move over a longer or shorter path; that is, its amplitude of vibration may vary. It may move over its path more or less frequently, oftener or fewer times in a second; that is, its period or rate of vibration may vary. But even if the amplitude and the frequency of its motion be fixed, as if it be condemned to pass from *a* to *b*

a ———————————————— *b*

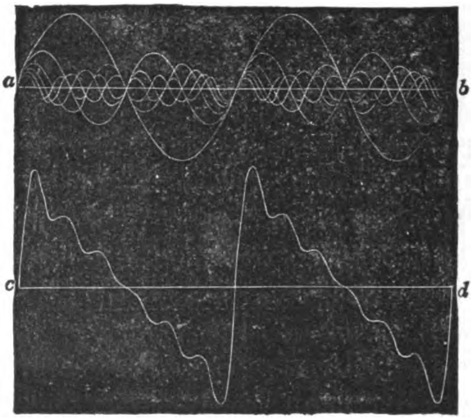
a certain number of times per second, it may pass over the path in a different manner each time. Thus it may pass from *a* to *b* with a uniform velocity, starting instantly and stopping instantly. It may have the gradually increasing and diminishing motion of the pendulum or the peculiar and irregular motion of the trip hammer or of the pile driver, or it may move part way at one speed, then go back part way on its path and then go on again. In short, even when the two extremities of its total path and the time allowed to pass from one to the other are limited, an infinite variety is still possible to its movement.

Passing from the phenomena of motion to those of sound, the amplitude of the vibration of the air particle means the loudness of the sound, the frequency of the vibrations — total passages from *a* to *b* — means the pitch of the sound, and the *character* of the motion means the character, quality or *timbre* of sound. Now "character," "quality" or "*timbre*" are what distinguish from each other sounds which agree in loudness or pitch, as the note of a piano from that of a violin, of a flute or of the voice, and which equally distinguish one voice from another, one vowel sound from another, one articulate sound from another. If, therefore, articulate speech is to be conveyed, we must produce and reproduce with accuracy not merely the amplitude and frequency, but the *character* of the vibration. What the speaker utters is heard and understood, not because his vocal organs produce *some* vibration, not because the vibration produced is of the desired *character;* and it is obvious also, inasmuch as a sentence can be spoken intelligibly by a man's voice or a woman's, in a loud tone or a gentle tone, that it is neither pitch nor loudness (as we commonly understand them) but *character* which is the one thing important for articulation.

From the graphic method of stating sound vibrations by means of curves (fully explained by Prof. Cross in his first affidavit, p. 31), it is common among scientific men to speak of the *form* of a sound vibration, meaning thereby what we have designated as *character*.

The word "form" is not here used in the sense in which a painter speaks of the form of a wave. Any variation, whether it be in the rise and fall of the price of cotton, or the rise and fall of the barometer, or the varying pressure of steam in an engine, can be and frequently is expressed by sign writing, consisting of curves which, when drawn, address themselves to the eye and to the sense of form. It is short-hand for a long verbal statement of the character of any change, be it of place, or of density of pressure, or of both (as in the case of sound vibrations).

We have said that amplitude of vibrations corresponds to loudness, frequency of vibrations corresponds to pitch, and form or character of vibration corresponds to "quality," character, *timbre* or articulation. The correspondence is extremely marked.



The curves *c d* (Cross, p. 33) can mathematically be resolved into the series of curves at *a b*, of which it is the algebraical sum. So every sound curve, no matter how complicated, such, for example, as those on pp.   is mathematically considered the sum of a series of sinusoidal curves, such as that on p. 31 or those at *a b* of p. 33. The eye cannot trace the resemblance, except that it notices that the crests of the compound curve corresponds in frequency with the crests of the largest of the component curves.

In like manner a sound made by the human voice (indeed nearly every sound to a greater or less extent) is, in the science of acoustics, treated as the sum or the combined result of a number of simple or pure sounds, each of which is the sound that would result from a vibration of the form represented by a single, simple, sinusoidal curve. Among these sounds there is one much louder than the others and almost always the lowest in pitch of the set (of less frequent vibration), which is called the fundamental. The curves *a b* are intended to represent six simple sounds; the louder and deeper the fundamental, the fainter and higher the overtones. It will be observed in these curves that it is the frequency (pitch) of the larger one (fundamental) of the series *a b* which determines the frequency of the crests of *c d*, while the office of the others is more particularly to give to *c d* its peculiar form between the crests. So the fundamental tone determines what the ear recognizes as the pitch of the compound sound.

The pitch recognized by the ear is not the *average* of all, but (with certain refined possible modifications not to be noticed here) is exactly that of the fundamental, while the overtones give to the sound its quality or *timbre* or articulate character. And thus a sound which the ear recognizes as of a given pitch, to wit, that of its fundamental, owes its *quality* to the number of overtones combined with it and to the pitch and loudness of each of them. It is obvious that there is room here for an infinite variety. It is the combination of overtones with the fundamental tone which gives to each sound its peculiar character and to the air vibrations which produce it their peculiar form.

When I speak in front of a closed door or thin partition, my vocal organs give to the air particles next to them the peculiar and special character of motion we have described. Those particles impart the same special vibratory motion to the particles next in front of them, and so on until the air particles next the door take the same motion; they in turn impart it (diminished but not changed in character) to the surface of the board with which they are in contact. The coherence of the material compels the farther surface of the door to move in the same way; this imparts the same kind of motion to the adjacent air particles, and so it is propagated till the air particles next the drum of the listener's ear take up the same motion, and impart it to the organs of audition. The listener then hears and distinguishes or understands what was uttered.

If we confine our attention to the closed door or diaphragm, it will be perceived that the essential thing there is, that the surface next the speaker must be so connected to the surface next the listener that not merely the one may move the other, but that the movement of the former shall compel the latter to take up the same character of motion, and do it truthfully in all those features and lesser variations which, as already explained, constitute *quality*.

Can a way be found by which those two surfaces can be separated by a distance of a mile, and yet, by means of electricity, that perfect connection be maintained, and that perfect obedience compelled? Mr. Bell found a way, and his patent disclosed it. The agent by which he accomplished it was electricity modified to conform to a new rule which he laid down.

State of the Art.

The most advanced instrument before Mr. Bell's time was the Reis telephone, which had been known since 1862. A stretched membrane was set in vibration by the voice or a musical instrument. It carried a contact piece which was the equivalent of one of the contact pieces of a Morse key, while the other contact piece was not attached to the membrane. Each time the membrane bulged in one direction it made contact, closed the circuit, and the battery current flowed; each time the membrane flew back the circuit was broken and the current interrupted. At the receiving end an electro-magnet and armature or some equivalent device was provided, which was moved in one direction when the current flowed and flew back when the current was interrupted. The frequency of this motion was therefore the same as the frequency of the interruptions; and as this depended upon the pitch of the note sung into the transmitter, it followed that the sound produced at the listening station resembled the exciting sound in pitch; but they resembled each other in nothing else; the apparatus, therefore, could not transmit articulation. The trouble was not that the parts were not well adapted to operate as intended; it was that the kind of operation intended and performed was incapable of transmitting *quality*. It could transmit *pitch* but nothing more. This is stated in Prof. Cross's opening affidavit, pp. 37, 38, and is not disputed.

At the present day it is obvious why such an apparatus cannot transmit articulation. The operator with the Morse key in Fig. 15 can make the armature move as often as he depresses the key, but he has no other control over it. When it comes down it comes with the full force of the battery, and always with the same force and therefore through the same distance. So a sound in front of the diaphragm of a Reis transmitter causes contact with the contact piece at the extremity of each vibratory movement. Each time it revisits the end of its path the full force of the battery is let on or shut off. A succession of separate electrical impulses, each of the same character, traverses the line. These can and do control the frequency of the movement at the receiving end and the pitch of the sound it produces, but nothing more. Mr. Bell's work was to accomplish something far different; it is certain that his method must be far different.

Mr. Bell's Invention and Patent.

Mr. Bell's patent 174,465, of March 7, 1876, describes certain instruments shown in Fig. 5; it states their use in a system of multiple harmonic telegraphy upon which he was engaged. He had pointed out (p. 15) that this instrument produced " an undulatory current of electricity " *such that its undulations corresponded in all particulars to the motions of the moving part of the transmitter.* His language is: —

> "the undulations of which correspond in rapidity of succession to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.
>
> "Electrical undulations induced by the vibration of a body capable of inductive action can be represented graphically without error by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air."

Having referred to harmonic telegraphy, he proceeded: —

> "I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind. When the armature *c*, fig. 5, is set in vibration, the armature *h* responds not only in pitch, but in loudness. Thus when *c* vibrates with little amplitude, a very soft musical note proceeds from *h*; and when *c* vibrates forcibly, the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So if A and B,

fig. 6, are sounded simultaneously (A loudly and B softly) the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

"One of the ways in which the armature *c*, fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in fig. 7, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument.

"The armature *c*, fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane *a*. A cone A is used to converge sound vibrations upon the membrane; when a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electro undulations are created upon the circuit E *d e f g*. These undulations are similar in form to the air vibrations caused by the sound; that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

"In this specification the three words 'oscillation,' 'vibration' and 'undulation' are used synonymously and in contradistinction to the terms 'intermittent' and 'pulsatory.'

And thereupon the United States found the following to be a true statement of his invention, and granted him the exclusive right to practise the same: —

Claim 5. "The method of and apparatus for transmitting vocal or other sounds telegraphically as herein described, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

Upon examining the foregoing quotations from the patent, the following is apparent: —

Mr. Bell pointed out that his instrument produced electrical *undulations* as distinguished from intermittences or interruptions; he pointed out that these electrical undulations corresponded in character — or, expressly referring to the nomenclature of the graphic mode of representation, corresponded in *form* — to the motion in the transmitter. He showed how this motion could be caused by, and therefore be a copy of, the aerial vibrations due to whatever the operator uttered into the transmitter. He pointed out that in using the apparatus Fig. 7, each action, beginning with the voice, is the creating or controlling cause of the next. He described the electrical link as follows: "These undulations are similar in form to the air vibrations caused by the sound; that is, they are represented graphically by similar curves." He states the result to be that "a similar sound to that uttered into A is then heard to proceed from L."

Now, comparing this with the Reis, we find the chief and characteristic novelty to be that the electrical changes employed by Mr. Bell — his electrical alphabet of speech — are such as he correctly describes by the phrase "electrical undulations similar in form to the sound waves." It is this novelty which enables him to produce his new result. This was the great invention which he made and dwelt upon in his patent. His special construction of transmitter is subsidiary thereto: it is for the purpose of enabling the voice to cause these peculiar electrical changes; his line wire is to enable them to travel to the other end; and his modifications in the receiver as compared with that of Reis are to make it so sensitive as to be more faithfully and more efficiently vibrated by them.

Meaning of Claim 5 *of Mr. Bell's Patent.*

The next question is, whether this invention is covered by his claim.

His claim is in terms for an apparatus and for a method concerning which the causing of "electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds" is particularly named, and is the only thing specifically named. Going back to the specification for the descriptive part to which this refers, we find that almost exactly the same language is used in the passage already quoted; and we find it there stated that it is this peculiar sequence of changes which causes the diaphragm of the receiver to copy the motion in the transmitter.

There can be no doubt, therefore, that the language of the claim is broad enough to include, and that the Commissioner of Patents intended that it should include, this invention, and should not be limited to one specific and precise form of instrument in which it could be embodied and by which it could be practised.

This is clear as mere matter of textual criticism of the patent. Considering the transmitter alone, the essential thing is that in its operation it shall at all times control the electrical condition of the apparatus with such effect that the changes in the latter shall at all times be similar in form to the unceasing motions of the former. Fig. 7 shows one form of transmitter which will do this, but the specification expressly states that neither the invention nor the grant of the patent is limited to that form. It says: —

> "There are many ways of producing undulatory currents of electricity dependent for effect upon the vibrations or motions of bodies capable of inductive action. Electrical undulations may also be caused by alternately increasing or diminishing the resistance of the circuit. . . . For instance, let mercury or some other liquid form part of a voltaic circuit; then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current, hence the vibration of the conducting wire in mercury or other liquid, included in the circuit occasions undulations in the current. . . . In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect."

The patent then proceeds to describe Fig. 5, and afterwards Fig. 7. It cannot be pretended, therefore, that the patent meant to protect him only so far as concerned the practice of his invention by the particular form of instrument shown. His patent shows that he understood and that the Office understood that the characteristic of his invention lay in this novel law of electrical change, and not in the form of instruments which went to make up his apparatus.

Moreover, the question is not an open one. The Commissioner of Patents decided it in 1879 (*Gray et al.* v. *Bell*, 15 O. G. 778). This court decided the same question in the same way in 1881 (*Am. Bell Tel. Co.* v. *Spencer*).

It is a settled rule that a claim may be, and if possible should be, construed as coextensive with the invention, and will cover all modifications of the apparatus which include any substantial part of the novel method or mode of operation introduced by the patentee (*v. infra*, p. 43).

As matter of construction, therefore, the patent is broad enough.

INFRINGEMENT.

The Facts.

The evidence brings the facts of this case within a very narrow compass; those which seem to us to be legally decisive are not disputed by the defendants.

The opening affidavit of Prof. Cross states at length the novelty set forth in Mr. Bell's patent to be what we have already briefly indicated. That he did these things, that he was the first to do them, that this novelty in operation is the efficient cause of his novelty in result, and that they are equally essential to the transmission of speech by the defendants' form of apparatus, cannot be and is not disputed.

The more common and usual commercial form of the Bell apparatus, using a variable-resistance transmitter such as the "Blake" or the "Edison," is described in Prof. Cross's opening affidavit (p. 21), is figured in his affidavit in reply as Fig. 1 (p. 20), and is stated by him to be not a departure from Mr. Bell's invention, but simply an improved form of it. This is not denied, and indeed is expressly admitted, by the defendants. Their witness, Prof. Farmer, says (p. 29), "The Bell system, in which I include generally all speaking telephones that I have heretofore known"; he had already mentioned (p. 27) that he was familiar with those forms of the instrument known as the "Blake" and the "Edison."

Prof. Cross's Fig. 1 is repeated in Mr. Pope's affidavit in rebuttal (p. 1) as the type of that form of the Bell apparatus in most common use.

Prof. Cross's affidavit in reply gives Fig. 2 and Fig. 3 as the normal forms of the defendants' apparatus, and their affidavit in rebuttal (Buck, p. 14) expressly agrees to this.

The comparison of these forms of apparatus reveals some resemblances and some appearances of difference. Do they resemble each other in using those special electrical undulations due to the voice at one end and employed to produce sound at the other, or are there such differences as exclude the creation, the presence and the employment of them? Because in one case they use Mr. Bell's principal novelty, and in the other they do not.

Howe v. *Morton*, 1 Fish. 588. SPRAGUE, J.: "The inquiry is, What is there in common between the defendants' machine and the Howe machine which is not in common between the Howe machine and the prior ones? or in other words, What do the defendants use that belongs to Howe? it being taken for granted that whatever is new in Howe's machine belongs to him and is secured by his patent; and it being insisted that nothing of that which is new and secured by his patent is used by the defendants in their machines. So that it is the question whether the defendants do use what belongs to Howe by his patent.

"And here I would remark that this inquiry excludes various matters which have, properly enough, been gone into as to the diversities between the defendants' and Howe's machines. No matter what the diversities are, or what additions to or modifications of Howe's original invention have been made by the defendants, if these new improvements are engrafted upon Howe's invention, secured to him by his patent. The defendants may have taken Howe's machine as the basis and means from which to make their improvements. If they have taken what belongs to Howe they have infringed, although with the improvements the machine may be much more useful than it would be without them. This is a well-known principle of patent law.

"We are to inquire what there is in the defendants' machines that is taken from Howe's; and this induces the necessity of a comparison in the first place between Howe's patent and what was prior, in order to determine what there is in Howe's that is novel."

Description of the two Forms of Apparatus and their Operation.

We can now compare the forms in accordance with this rule: —

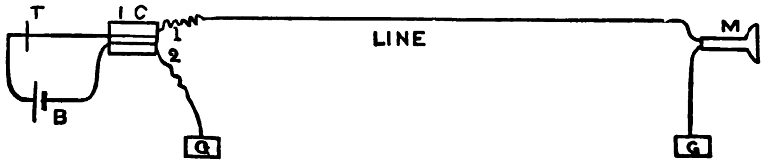


FIG. 1. PLAINTIFFS' BELL APPARATUS.

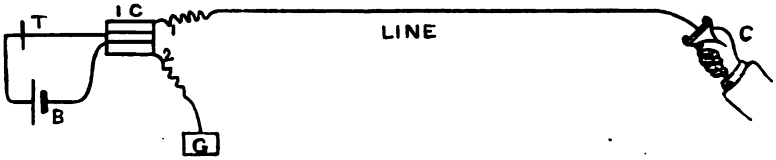


FIG. 2. DEFENDANTS' APPARATUS.

Fig. 1 is the ordinary form used by the plaintiffs; B is a battery; T is a Blake or Edison transmitter; the wire circuit which includes these also includes the primary or interior helix of an induction coil I C. This circuit is complete and continuous, and is supplied with a constant energy or electro-motive force from the battery B. The diaphragm of the transmitter T moved by the voice causes corresponding changes in the electrical resistance of that part of the circuit which passes through it, and therefore corresponding undulations in the current.

The induction coil includes a secondary helix wound outside of the primary; one end of this secondary helix is prolonged or connected from 1 to the distant station, forming the line wire.

The primary helix and the secondary helix are so insulated from each other that the current from the battery circulates in the former, but never passes into the latter, nor to the line. But they are so placed with relation to each other that by an old and well-known law every variation of the electrical current in the primary produces a corresponding electrical disturbance in the secondary. Thus every electrical disturbance produced by the transmitter T is propagated to the magneto receiver M at the receiving station with the same fidelity as if both were connected by a single wire: the employment of the induction coil, however, greatly increases the intensity of the electrical changes. This was the type of apparatus which was held to be an infringement by this court in the Spencer case, and by the Commissioner of Patents in *Gray* v. *Bell*, O. G., May 13, 1879, vol. 15, p. 778.

Electricity in a conductor behaves in some respects so much like a fluid in a pipe, that it is common to illustrate its action by such a comparison: —

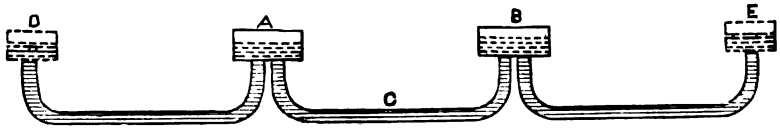


FIG. 10.

Let A and B be two reservoirs connected by a pipe. Suppose the liquid in A to be higher than B, or *vice versa;* the fluid will flow in a current from one towards the other until the pressures become equal. If a piston be inserted at C, the flow will be obstructed and the force of the head will be exhibited as pressure on the piston and thus move it.

Suppose, again, the liquid in A and B being at the same height, the piston in C is moved towards B: this will produce a flow towards B, which will no longer be due to but will cause an increased head and pressure in B, and a diminished head and pressure in A. If the reservoirs A and B had previously been connected with a third D and fourth E by pipes, the diminished pressure in A would cause a current D to A, and the increased head in B would cause a flow from B to E.

Thus any force which disturbs the equilibrium, and conversely every effort of the system to regain its state of equilibrium, *is manifested both as current and as change of pressure;* and whichever is primarily caused by external force becomes in itself the cause of the other.

It will be observed, also, that the direction, the duration and the violence of all these changes follow one law; that is, the will or character of the disturbing force, to which one is immediately and the others mediately, but as directly, due.

The nature of this apparatus imposes one limitation. If A and B are small compared with the size of the pipe, the pressures will soon equalize and the flow will stop. So if they are small, and we work the piston at C, B will quickly receive all that can be forced into it.

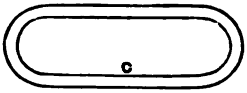


FIG. 11.

If we make our pipe in the form of a ring we can work the piston C forever. But if all we have occasion to employ is a current of excessively short duration, involving the transfer of a small quantity of liquid, as if the piston were to pulsate or required to be made to pulsate rapidly backward and forward through a very small distance, the form Fig. 10 will be about as good as that of Fig. 11.

Obviously, we *can* get a greater pressure by working the piston in Fig. 10 than by working it in Fig. 11, if we pump until B becomes entirely full to bursting. But we also obtain pressure in Fig. 11, and could even in a pipe with an open end, — witness the bursting of fire-engine hose. Indeed, it is this pressure which causes the current in the ring-pipe.

In all these cases an increase in the force applied increases the flow; an obstruction in the conductor diminishes the flow. For some particular purposes a great increase may be harmless, but unnecessary, or the diminution may still leave sufficient.

Substitute *electric potential* for *pressure* or *head*, and *electro-motive force* for the external power applied to the piston, and the foregoing becomes a convenient representation of what takes place in the two forms of apparatus we have to consider. Indeed, a recent investigator has been able to copy many electrical phenomena by the pulsation (without continued flow) of liquids confined in conducting tubes and elastic reservoirs.

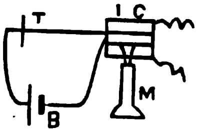


FIG. 12.

In this Fig. 12 we have so much of the apparatus of Figs. 1 and 2 as is found at the sending station. The motion of the transmitter T varies the resistance of the primary circuit, and thus the voice produces therein electrical undulations similar in form to the sound waves; these undulations are here especially manifested as variations in the strength of a battery current.

The induction coil consists of a primary helix forming part of the same circuit which includes the battery and transmitter. Outside of this is the secondary helix, consisting in the ordinary forms of the Bell apparatus of one hundred and fifty or more yards of fine copper wire. Less will do and ten times as much may be employed.

This secondary helix and connected wires are normally in a state of electrical inactivity.

Every change in the primary current disturbs the electrical equilibrium of the secondary helix, forces its electricity to flow towards and accumulate at one terminal, say 1, the potential of which is thus raised above the normal, while that of 2 is correspondingly lowered below the normal; when the converse change takes place in the primary current, the flow in the helix is reversed in direction.

When the point 1 is connected to any distant body, the varying potential of 1 causes a corresponding flow towards or from that distant body, and a rise and fall of its potential.

Inasmuch as all these steps bear to each other the simple relation of cause and effect, it follows, and is a well-known fact, that the voice, acting on the transmitter and directly affecting the primary circuit, equally controls and as faithfully causes electrical undulations similar to the sound waves in all the parts mentioned. These are manifested both as variations of potential and as variations of current.

A fuller statement of this, with quotations from standard writers, is found in the second affidavit of Prof. Cross, pp. 9–17, Mr. d'Infréville, page 50, and is not denied by the defendants in reply. Both forms of apparatus employ the same instruments at the sending station to produce these undulations, and a line wire to convey them to the listening station.

Identity between the two.

The defendants expressly admit that in both their form and the more usual form of the Bell invention,

> ' electrical variations corresponding in form with the air, vibrations produced by the utterance of speech are set up in the line wire." (Trowbridge, p. 27.)
>
> " He [Bell] throws upon an electric circuit variations like those which the utterance of a sound has produced in the air, and the same is true of my telephone." (Dolbear, p. 5.)
>
> " It is true that by Mr. Bell's method air waves produced in speaking are caused to vibrate the instrument which holds the electric circuit under its control constantly, so that whatever movements of the diaphragm at any instant may be made *will be converted into a corresponding electrical variation on the line wire. And I do the same.*" (Dolbear, p. 6.)

Prof. Trowbridge adds to his remark already quoted an emphatic assertion that it is *by means of these undulations* that the defendants transmit speech.

> " Unless this is done it is physically impossible that speech should be transmitted by electricity."

Mr. Pope also, comparing the *apparatus* merely, describes that part of the defendants' form which is at the sending station, and then says (p. 21) : —

> " Thus far the apparatus of Dolbear is substantially the same as the apparatus which is employed in the telephones in general use.

The apparatus at the receiving station, however, is radically different from that of Bell in its construction, principle, and mode of operation."

The defendants' statement therefore is that *no difference of substance is met with until we reach the listening station.*

In his affidavit in reply, Prof. Cross begins as follows (p. 1): —

> "In my previous affidavit I stated that electrical undulations similar in form to the sound waves were produced in the Dolbear apparatus by the sound waves themselves at the sending end, and were the cause of the sound waves heard at the receiving end."

Mr. Pope's affidavit in rebuttal, p. 12, quotes this with the comment, "This is unquestionably true."

The Differences are confined to the listening Station: what they are.

Having caused at one station and conveyed to the other these electrical undulations novel with Mr. Bell, the remaining work is to there employ them to produce corresponding sonorous vibrations in the air. Both do this; but the undisputed resemblance comes closer still. Both provide a metallic diaphragm or disk supported at its edges, and subject it at its central and free part to an attraction due to and therefore varying in a manner similar in form to these electrical undulations. For this particular step one employs one well-known property of the electricity which has thus reached the listening station, and the other employs another well-known property of the same electricity.

The same arm and hand, moved by the same, will shake the same plate; it merely took hold of it by a different handle.

The Bell magneto-receiver is constructed as follows (omitting the mouthpiece): —

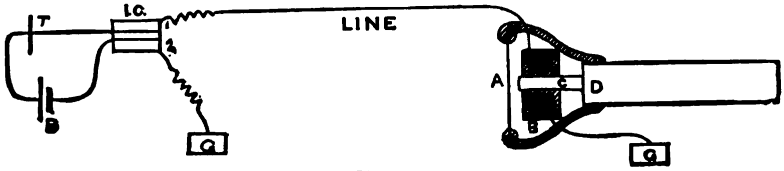


FIG. 12.

A is a thin circular plate of iron supported by its circumference near to but not touching C, the core of an electro-magnet which is fastened into the end of a magnetized steel bar D. B is a coil of fine insulated wire surrounding the core. When a current flows through the coil B, the magnetism of the core C is increased (in a given case) and A is pulled towards it; when the current slackens A flies back more or less. Inasmuch as the pull on A varies with the flow through the coils, the vibratory motion of A obeys the same law as the electrical variations on the line, and therefore its motion corresponds or is similar in form to the rise and fall of the electric potential at 1, which, we have already seen, is due to and is similar in form to the sound waves acting on the transmitter T.

The defendants' condenser-receiver and connected parts (omitting some details not material to the inquiry under Mr. Bell's first patent) are constructed as follows: —

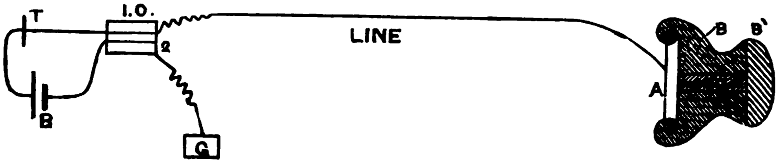


FIG. 13.

A is a thin circular plate of iron held at its edges, and separated by thin insulating rings from another plate B. B is so held that it cannot vibrate, and the metal rod C places it in electrical connection with the mass of metal B′. This again is usually and preferably grasped by the operator, and thus electrically connected with his body. The line wire connects the front plate A with the terminal 1 of the secondary helix of the induction coil.

Whenever the potential of the front plate A is changed by an inflow or outflow of electricity along the line wire, the attraction between A and B is changed and A moves. The force of the attraction is measured by the change of potential of A, and therefore the movement of A obeys the same law. The movement imparted to the transmitter by the voice controls the motion of A (of which it is the cause) *by means of the electrical undulations described*, and compels A to conform to its motions because all those electrical undulations are similar in form to the actuating sound waves; this is true of both forms of apparatus, and is the reason why they transmit speech.

This comparison is found in Prof. Cross's affidavit in reply, p. 5.

Nature of the Difference.

Some of the first affidavits of the defendants appeared to intimate that the two forms of apparatus employed different kinds and inconsistent kinds of electricity. But the evidence of Prof. Cross, Mr. d'Infréville and Prof. Wright in reply left it clear that the foregoing statement is the correct one. This indeed was substantially stated by Mr. Farmer in the defendants' first set of affidavits, and by Mr. Pope in those filed since ours in reply. It is stated and summed up by Prof. Cross on pp. 6, 31; Mr. d'Infréville, p. 51.

Mr. Cross, after describing what takes place at the sending station and on the line wire, and the various properties of electricity there employed, continues (p. 6): —

> "All these properties and the manner of using them being the same in both, the difference consists in this: that when, by virtue of these properties and the particular construction and operation of the transmitter and line wire (being the same in both), the electricity reaches the receiving end in precisely those measured variations of quantity which Mr. Bell was the first to produce, and which are essential for speech, the one person utilizes one long-known property of electricity to make these variations perceptible to the ear, and the other uses another long-known property.
>
> "This is correct, but it is not all. I add to it the fact that it was known before Mr. Bell's time that both these properties might be used as a means of making electrical variations sensible as sound vibrations."

In his subsequent affidavit in rebuttal, Mr. Pope gives the following as his statement of the Bell method, and of what he is pleased to call the "Dolbear method": — *

Dolbear himself admits that he uses Bell's novelty up to the receiver, and as the work he does is precisely that which Mr. Bell was the first to do at all, the witnesses should invent some phraseology to describe what Dolbear added, and to give Bell the credit for what he taught Dolbear to do. Dolbear cannot describe all his alleged work in an operative or practicable form except by also describing what he adopted from Bell.

---

* The defendants' witnesses repeatedly speak of the "Bell method" and the "Dolbear method"; the "Bell system" and the "Dolbear system." Certainly Mr. Bell's work, which first gave to the world the fruits of a new victory over nature because it introduced a new method and a new system, deserves words which signify dignity and importance; but the same cannot be said of the defendants, who (whether from Dolbear's invention or not) have merely replaced Bell's receiver by another receiver without substantial change of result. This habitual application of the same term to both must be either because the defendants' witnesses do not feel the difference of grade which separates these two inventions, or because they hope the Court will not.

P. 8. "The two methods respectively utilize two wholly unlike properties or characteristics of the electrical energy which is manifested in the secondary of the induction coil at the sending station."

Mr. Pope does not notice that all the properties in virtue of which the undulations are produced and propagated are the same in both.

P. 10. "This experiment shows what Prof. Cross himself admits (pp. 31, 32), — that the electricity in the conductor has two properties, and that if we place the two receivers (the magneto and the condenser) side by side in the same conductor, one property moves one and the other property moves the other."

Here too Mr. Pope does not care to even notice that what gives the sole value to the apparatus is not the fact of motion, but the kind or sequences of motion; and that for this it is of no consequence which of these two properties is employed, but that it is essential that the electricity possessing these properties should arrive in that measured sequence first mentioned, first caused, and first employed by Mr. Bell. The essential thing is that the law of change according to which the amount of electricity present at successive instants varies shall be the rule laid down by Mr. Bell.

Mr. Pope continues: —

"I believe Dolbear to have been the first to discover that one of those properties of electricity (that which he uses) could be made available for the utilization of magnetic variations of the peculiar kind necessary to produce articulate speech."

The "variations of the *peculiar kind necessary*" are Mr. Bell's novel kind; Mr. Pope's statement, therefore, is merely, that the defendants, in his opinion, have found that these variations possess another property by which they can be converted into sound, in addition to that property which Mr. Bell employed for the same purpose, provided the amount present to be used varies in accordance with Mr. Bell's rule.

Bearing in mind Prof. Cross's repeated and undisputed statements that Mr. Bell's great novelty consisted in the peculiar succession of the electrical changes or the peculiar "form" of the electrical undulation, this language, in which Mr. Pope's final affidavit thus summed up all that he ventures to *claim* for the defendants, is a definitive statement that at the last step in the long operation, and for the purpose of converting the same sequence of electrical undulations into a corresponding sequence of motions, one lets the electricity exhibit itself by one of its known modes of manifestation and the other by another known mode.

It cannot be denied that both employ Mr. Bell's novel and peculiar kind of variation produced by his novel and peculiar means, as *the* essential for attaining by their apparatus the result which gives value to both forms.

We let Mr. Bell's undulations manifest themselves in motion by one known property, and they let them manifest themselves *in the same motion* by another known property. We employ that well-known property of electricity which enables it to give the power of attraction to a bar of iron around which it passes in proportion, the amount passing in a given instant; they employ the other well-known property of electricity which enables it to give the power of attraction to a mass of metal into which it has flowed, in proportion to the amount of electricity which, the mass remaining unchanged, has reached it at any given instant.

That which they have in Common is essential and is the chief Novelty of Mr. Bell's Work; the Difference is unimportant.

Suppose an apparatus like Fig. 1, but employing some third type of receiver, had existed before Mr. Bell's time, and Mr. Bell's novelty had consisted merely in introducing a magneto receiver to perform the subordinate function of the older form, and that subsequently the defendants had replaced the original receiver by a condenser receiver such as they use: it would then be true (if they had not copied any of Mr. Bell's details of construction) that they would not have used his invention, thus limited to the receiver, and would not have been beholden to him for anything they had, but both he and they would have been beholden to the prior constructor. Now, Mr. Bell is that prior constructor also, and the whole defence of these defendants is an attempt to narrow Mr. Bell's invention and his patent to what it would be if he had merely introduced a new form of receiver into a previously known speaking-telephone apparatus, without changing the essential character of the operation and result.

Mr. Bell did invent special details and features in each part of his apparatus; but the great invention consists in the apparatus as a whole, in the new departure in the arts and in the results due to the novel operation of the apparatus as a whole.

It is because of what is common to both that theirs is usable.

The gulf between the character of the operation of the apparatus used by Reis and the character of the operation performed by the precise form of apparatus used by the defendants is enormously great considered *per se* as well as with reference to the consequent result. Now Mr. Bell's work filled the largest and most difficult part of the gap. They propose to travel over nearly the whole of the road he made, and to reach the same market at the end, but avoid the toll gate by a shun pike at the end of the journey.

It is true that the details of construction which are most favorable to the cheap and easy exaggeration of the one property are not the same as those which are most convenient for the exhibition of the other; but they are merely different properties of the same thing, and the experiments referred to on p. 28, *infra*, show that in the defendants' apparatus as they construct it, both properties are so efficiently developed as to work both kinds of receivers. This is not denied by the defendants' subsequent affidavits, though they apply to the relative loudness of the results, adjectives quite different from those which were justified by the tests made by our two independent observers, Prof. Cross at Boston and Prof. Wright at New Haven, and Mr. d'Infréville. Mr. Pope, however, appears to have made a single test, aided by Dolbear's assistant Buck, on April 12, 1882 (p. 2). Prof. Cross repeated all of his on different days, and some of them many times (pp. 19, 20).

Currents.

The flow of electricity and the rise and fall of potential are not different phenomena: they are different manifestations of the same thing; they accompany each other. In the two forms of apparatus you cannot have one without the other.

There was an intimation in the first affidavits for the defendants that there were no "currents" in the defendants' form of apparatus. It is not material as matter of law whether there are or not: Mr. Bell's patent is not limited to "currents," either in terms or by necessary inference from the nature of the subject. They confessedly exist in the primary circuit; and it is to the existence there of undulatory currents similar in form to the sound waves that the whole operation of the apparatus is due. Mr. Pope says (defendants' affidavits, p. 25.): —

> "My attention has been called to the statement in Prof. Cross's affidavit, that both the instruments [Bell's and Dolbear's] form parts of an apparatus which, as a whole, transmits speech by means of certain peculiar variations of electrical currents; if this means that Dolbear uses a complete electrical circuit as part of his transmitter, in which circuit, for the purpose of inducing magnetic changes in the transmitting core, such variations of an electrical current are employed as Bell employs in the circuit in which his receiving core is placed, the statement is correct."

Prof. Cross means this; but he means also that it also employs currents on the main line which vary from instant to instant in accordance with the same law (or "form") of change.

This is again stated in reply by Prof. Cross (pp. 8–13), Mr. d'Infréville (p. 51); the subsequent affidavits for the defence do not point out any such limitation in the patent. But in fact, true "currents" of the special kind ordinarily used in telephony (transient currents of extremely brief duration and rapidly reversed) are found in the defendants' apparatus. Prof. Cross examined this on p. 7 of his affidavit in reply, and showed that they did there exist in the sense in which that word is ordinarily used by standard writers. Prof. Cross, Mr. d'Infréville and Prof. Wright then actually demonstrated their existence in all parts of defendants' apparatus; they looped in magneto-receivers and got good results from all. The following diagrams taken from their affidavits sufficiently indicate the character of this proof. In all these cases both kinds of receivers were used and gave speech. M is the Bell magneto; C is the defendants' condenser receiver.

It is true that the defendants dam up the stream to get a greater head; but they could not fill and empty their mill pond several thousand times a second without a current flowing in and a current flowing out, nor could the electricity from the sending end affect the other unless it flowed thither.

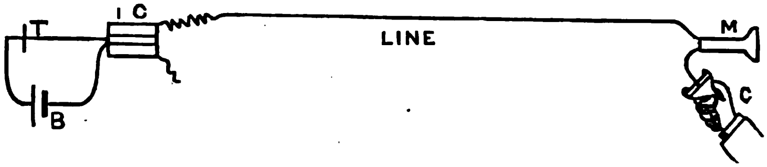


Fig. 3.

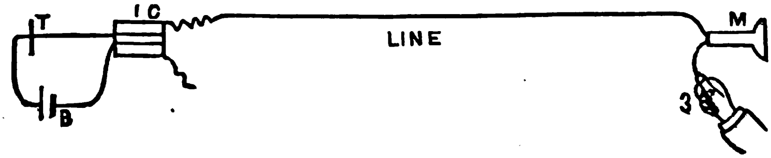


Fig. 4.

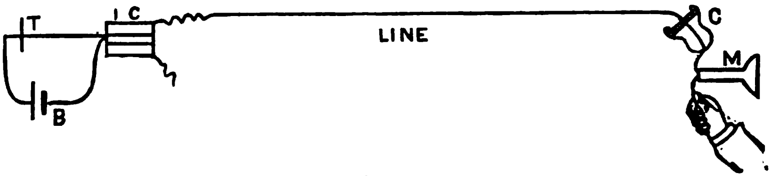


Fig. 5.

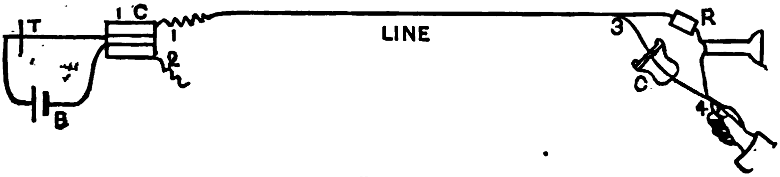


Fig. 6.

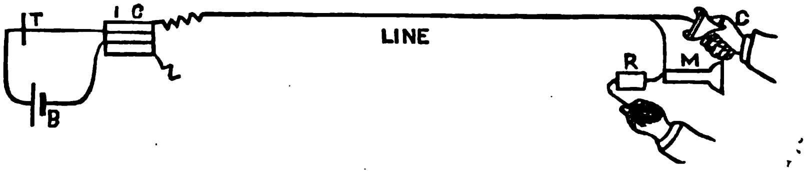


Fig. 7.

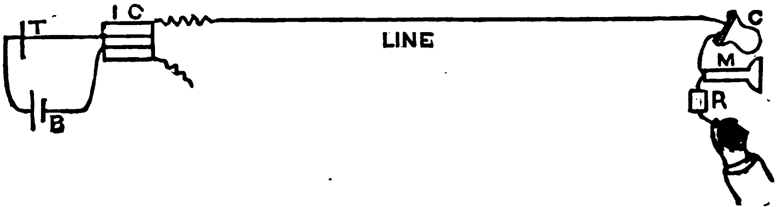


Fig. 8.

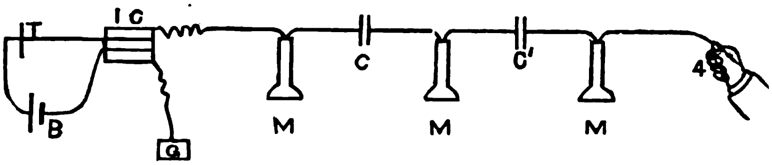


FIG. 9.

Value of two of the Defendants' Witnesses.

The comparison of the defendants' affidavits in chief and in rebuttal leaves two of their witnesses in an unenviable position. Mr. Dolbear says (p. 9) : —

> "In Bell's method variations in current strength are essential, while in my method the electric variations are static." . . . In his own "there will be no current but simply electric tensions or electric pressure in the secondary coil." Page 10 : "It is impossible to apply the electric energy active in Bell's method to work my receiver, and impossible to apply the electric energy active in my method to work Bell's receiver."

This is of the gist of his defence.

Prof. Cross and others looped magneto-telephonic receivers into every part of what Mr. Dolbear calls his form of apparatus and invariably got speech both from the magneto and the condenser.

In reply, Mr. Buck, Mr. Dolbear's assistant, not denying the results in substance, says that he knew them all before and had repeatedly tried the same experiments.

After this it is needless to comment on the worthlessness of testimony from Mr. Dolbear's laboratory.

We desire to say that we do not concede that Mr. Dolbear was the first to conceive of the use of a condenser receiver in a speaking telephone. We are instructed that several persons preceded him in this. Nor do we suppose that the substitution is of any practical value. Neither of these inquiries however seem to be material to this case ; and, if they are, the defendants have offered no evidence to support their side of the inquiry.

The Difference relied on by Defendants.

Prof. Cross's opening affidavit contains the following (p. 45) : —

"The receiving instrument described in said affidavit of Edward Davis is not in all respects the same as that of Mr. Bell's said patent, but it is substantially the same in performing the work of the electrical transmission of speech according to the method shown in Mr. Bell's patent 174,465, and claimed in claim 5 thereof. Both the instruments form part of an apparatus which as a whole transmits speech by means of certain peculiar variations of electrical currents. In this apparatus the office of the instrument at the receiving station is to convert these electrical undulations into corresponding sound waves; and the particular means employed for that part of the operation do not affect the substantial identity of the apparatus as a whole. There is, however, a great identity between these parts of the apparatus considered by themselves. In both, the sound heard by the listener is produced by the vibrations of an electric plate, and in both those vibrations are caused by the varying attractions to which it is subjected by the varying strength of the electrical undulations in the line wire. It is true that in the form shown in the two Bell patents the variation of currents causes magnetic variations in a piece of metal opposite the centre of a diaphragm, the attractive power of which piece is thereby caused to vary accordingly, and thus cause variations in the attraction, while in the Dolbear instrument the variation of current causes electrical variations in a piece of metal opposite the centre of a diaphragm, the attractive power of which piece is caused to vary accordingly, and this causes variations in the attraction exercised on the diaphragm."

Inspection shows that this is correct, and the defendants' affidavits do not deny it.

The only essential thing in the receiver is that it shall be able to receive the electricity which comes to it varying in precise uniformity to the sound waves at the sending station, and that such character of variation should compel it to repeat the sounds uttered. This is the law of its operation, and the limitation within which all changes of construction must be included. It does give out such sounds by reason of varying degrees of attraction between different parts due to and corresponding to those electrical variations.

Mr. Pope's affidavit in rebuttal, p. 12, does not help the defendants. He has already sworn that the transmitters are the same in respect of that which relates to Mr. Bell's novelty; he now adds that in action they both produce electrical undulations similar in form to the sound waves, which is Mr. Bell's novelty; that these electrical undulations as found in the defendants' apparatus will operate Mr. Bell's receiver and make it talk; and that the result of the whole is the transmission of speech, for which he says these peculiar undulations are necessary. If after that he finds any substantial difference, it must be differences in those things which are in the nature of improvements in the use of Mr. Bell's novelty (if they offer practical advantages, which we deny), and not exclusions of it.

The whole substance of Mr. Pope's denial for the defendants is found on p. 24 of his first affidavit. The first part of the paragraph, which contains the denial of infringement, is merely what he deems to be the conclusion of the law from the assertions of the latter part. The questions for the Court are, whether the latter statement is true in fact, and whether if true it requires the law to say that using the novelty introduced by Mr. Bell, and specified in his claim, and which they say they cannot get along without, is not "using his invention."

The paragraph of Mr. Pope is as follows (p. 24): —

> "It is therefore my opinion that neither the combination of apparatus employed by the defendants for the transmission of vocal or other sound, or the method, means or process by which said apparatus is operated, is the equivalent of that described in the patent of Bell, inasmuch as one essential element of his combination of apparatus, and one essential step of his process, is omitted, *and nothing is substituted therefor which was known as an equivalent at the date of filing the application upon which the patent of Mr. Bell was issued.*"

It will be observed that Prof. Cross had stated three propositions. One was that both forms of apparatus exactly conform to the claim, viz., both transmit speech by causing electrical undulations similar in form to the sound waves, and that this is of the essence of both. The second was that the forms commonly used by the plaintiffs consisted of certain component parts, each performing its own special function in co-operation with the others in the general work done by the apparatus as a whole, and that each of these parts found, in the defendants' apparatus, its corresponding part, performing the same function *per se* and co-operating with the others in the same manner to enable the apparatus to accomplish the same work as a whole; and thus the change made by the defendants consisted in replacing a single one of those parts (or more strictly a portion of one of those parts) by another, which was its counterpart and equivalent. The third was that the receiver by which they had replaced Mr. Bell's receiver (or more especially that part of it which served to attract the diaphragm) was not only a substitute, but was, at the date of Mr. Bell's patent, known to be a substitute for the one it replaced.

Now the affidavits of Mr. Pope expressly admit the first, and substantially if not expressly admit the second. His summing up is limited to a denial that it was *known* to be a substitute at the date of Mr. Bell's patent.

We infer from this that the defendants intended to rely on a rule sometimes applied to a different class of patents, — those for mere technical combinations of old parts in the nature of improvements in existing machines. That rule is sometimes said to be that a patent for such a mere technical combination is not infringed if one member be replaced by another, unless the new member not merely is, but at the date of the patent was known as, an equivalent or substitute for the old. Their assertion is that they have used as a substitute for one part that which was not *known* as a substitute.

The Difference relied on by Defendants does not exist in Fact, and is immaterial in Law.

It is now our object to show, as matter of law, that no such rule exists or applies in the case of a patent for a new kind of machine, nor in the case of a patent for a *method* or process; and to show as matter of fact that the statement of Prof. Cross is correct.

We will state the previous knowledge on the subject.

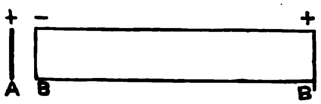


FIG. 15.

Suppose B to be a bar of iron or other conducting material which has recently been in contact with the earth, but is insulated therefrom and is electrically neutral or at rest. Let A be an iron disk also insulated and electrically neutral, in front of and quite near to one end of B, but insulated therefrom: the whole system composed of A and B will be electrically neutral. If now we pour into A, say, positive electricity, it will not flow thence to B, because of the air or other insulator between them, but acting by induction or influence through the intervening air, it will so affect B that the electricity in B will be driven away from the nearest end B, towards the farther end B′. The potential of B′ will be raised above and that of B lowered below the normal. It is forcing the electricity into A which does this work.

It is also a well-known fact that if two electrically charged bodies are brought near to each other, they will attract if of opposite signs (+ and —) and repel if of the same sign (+ and + or — and —). Thus, in the case shown, A will be attracted to B; if free to move will be drawn towards it, and the power which draws it is furnished by the force or energy expended in forcing the electricity into the plate A. It follows also that a careful measurement of the electric potential (or electric disturbance from the normal condition) of the points B or B′, or a careful measurement of the attraction between A and B, furnishes a measure of, because it corresponds to, the amount of electric energy poured into A and to which these effects were due.

All these facts were well known and were used long before Mr. Bell's time.

If the bar B B′ were reduced to the length of one thirty-second of an inch, the same kind of effect would be produced; but as the + and the — electricity would have very little room to separate themselves in, and as the + would be almost as near to A as the —, the practical effects would be much less marked: still they would be perceptible.

The following is a cheap and convenient form for the apparatus.

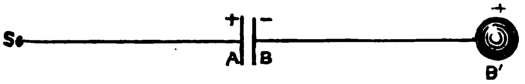


FIG. 16.

B B′ here takes the form of a plate B and a mass of conducting material B′, connected by a conducting wire; A is also provided with a wire which leads to S, the source of electricity, so that it can be conveniently charged.

It will be observed that B′ contains + electricity just as A does; this also can be utilized to disturb and to attract another conductor, and thus we arrive at the form Fig. 17.

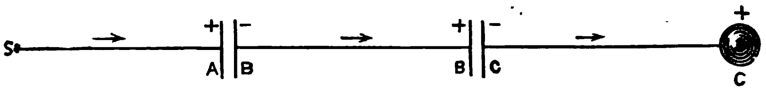


FIG. 17.

In this we shall find, when electricity is poured into A from S, that —

1. The parts will take the signs indicated on the diagram.

2. A and B will attract each other; B′ and C will attract each other.

3. Electricity will flow from S to A.

4. The electricity of the insulated body B B′ accumulates at or near B′; and to do this, all that was not there already flows towards B′ in the direction indicated by the arrows during the brief space required to effect the accumulation.

5. The same flow takes place in C C′.

6. The violence of this flow corresponds to the amount which is to reach B′ or C′ and be accumulated there.

7. If S be employed not to pour + electricity into A, but to abstract electricity therefrom, so as to give A the sign —, then all the signs will be reversed and the direction of the currents will be reversed.

8. As all these actions and changes are due to the energy of the source S and to nothing else, it is evident, first, that S will control all these actions, and second, that in frequency and violence they will correspond to the changes at S; or in other words, all these actions will be graphically represented by the same curve which represents the changes at S. Their direct correspondence was so well known that the observation of a change in either the energy of S, or the flow in the wires, or the absolute amount of electricity poured into A, B′, C′, etc., or the potential to which they were raised, furnished a measurement of the change in all the others. This was a well-known method for practical measurements.

From what has been said on p. 18, *supra*, it is evident (the supply at S and the capacity of the conducting wire being relatively large in the apparatus we shall have to consider) that A, B, B′, C, C′ may be very small in an apparatus which employs only the delicate, transient and rapidly reversed currents of the telephone.

The electrical capacity and the violence of all the operations in the whole system are increased by increasing the capacity of B′, the last end of the last member B B′ of Fig. 16, or of the body C′ of Fig. 17. It is common to use the earth for this body, but for all purposes in telephony the body of a man is of ample capacity. A sheet of iron a few inches in diameter will give practical effects.

The arrangement of the two plates A and B quite near to but insulated from each other is called a "condenser," and each plate is called an "armature" of the condenser. The Atlantic cable has been worked with apparatus of this description from a very early day. Its arrangement is shown in the following diagram and description found in Prof. Cross's affidavit, p. 20, and there quoted from a standard writer, Fleeming Jenkin.

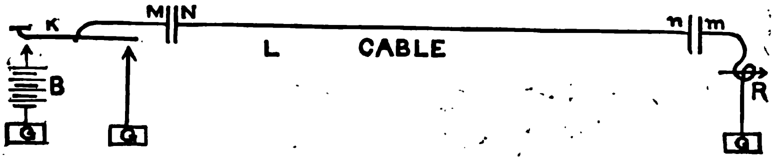


FIG. 18.

Comparing this contrivance with Fig. 17, it will be seen that the battery B and key K correspond to the source S, and send a positive charge into M along the connecting wire. That rearranges the charge in N *n*. That drives the + electricity from *n* to the end C′, which in Fig. 18 is the earth G; it passes as a current through all the wires, including that between *n* and G (C and C′), and on its way works the galvanometer receiver R commonly used in ocean telegraphy.

Comparing the defendants' condenser receiver (Fig. 13, *supra*) with the apparatus shown in Fig. 16, p. 33, *supra*, the identity in construction and operation is evident, and is sufficiently indicated by the corresponding lettering.

It will also be observed that breaking the conductor by the interposition of a condenser does not interfere with such flow and such transmission of electrical impulses as the speaking telephone employs, or even such as a much more sluggish instrument, the cable galvanometer, requires.

FORMER USE OF THE CONDENSER AS AN ACOUSTIC RECEIVER.

Moreover, the condenser was known at the date of Mr. Bell's patent as the equivalent of and a substitute for the magneto receiver in such systems for the electrical production of sound as were known.

Prof. Wright, of Edinburgh, made two forms of condenser receiver and employed them in the following kind of apparatus: —

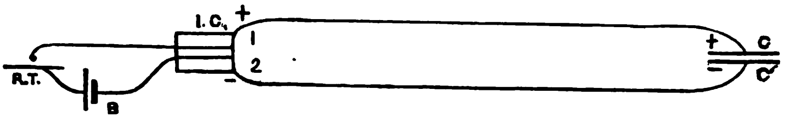


FIG. 19.

R T was a Reis transmitter which, when sung to, alternately made and broke a circuit which included a battery B and the primary helix of an induction coil. Whenever the circuit was closed at R T a momentary current was generated in the secondary helix, raising the potential of 1 and causing a flow towards C which filled C with + electricity. The same action lowered the potential of 2 (or drove the negative electricity to 2), and this determined a current from C′ to 2 and gave C′ the sign —. The plates C and C′ then attracted each other and their motion gave forth a sound. This is not the exact form of the receiver he used, but it was a condenser, and there can be no doubt that the second one, described by Ferguson in 1867, operated essentially in this manner. (See Prof. Cross, pp. 33, 44; and Prof. Wright, pp. 65–70.) This was known to Mr. Dolbear, and is described by him in his book and his patent. (Cross, pp. 44, 46.)

In 1863 Mr. (now Sir William) Thomson, using a condenser made of two plates of metal separated by an air space of .007 inches, observed the sound produced on the charge and discharge of a condenser, and published the fact in a communication entitled "*Sound produced by the Discharge of a Condenser.*" (See Prof. Cross, p. 34.)

In 1870 Cromwell Fleetwood Varley, the electrician to whom the previous practical introduction of condensers on the Atlantic cable was due, took out English patent 1,044, April 8, 1870, for a system of harmonic telegraphy. The foregoing diagram, Fig. 19, may be used to illustrate one part of his apparatus. A vibrating-reed circuit-breaker placed at R T made and broke the primary circuit, say, two hundred times a second. This, two hundred times a second, sent a secondary current from 1 to C and C′ to 2, and two hundred times a second produced a current from C to 1 and from 2 to C′. At the receiving station he desired an instrument whereby these electrical changes should be translated into sound waves, and which should do this by enabling each successive electrical impulse to move some vibrating body which in turn would vibrate the air. For this purpose he described and employed several types of instrument. In one the successive impulses passing around the coils of an electromagnet alternately magnetized and demagnetized its core; and then its armature gave forth a sound, the pitch of which corresponded to the frequency with which the electrical changes succeeded each other. *Another type consisted of a true condenser made of many plates and not of two only.*

A full description of these instruments is found in the affidavits of Prof. Cross, pp. 33, 35, 36; Prof. Wright, pp. 63–65.

The following diagram, taken from Prof. Wright's affidavit, p. 64, shows Varley's arrangement: —

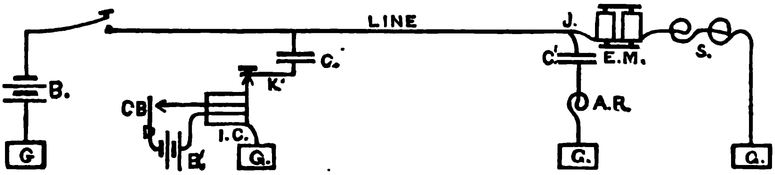


FIG. 20.

It is, moreover, a fact, proved by the actual trials made by these gentlemen, that the two condenser receivers of Dr. Wright and the condenser receiver of Varley, just as they were made before Bell's patent, will, when substituted for the Bell magneto receiver in the form of Bell apparatus Fig. 1, or for the defendants' condenser receiver in the form Fig. 2, and subjected to Bell's articulating undulations, act as speaking-telephone receivers and reproduce articulate speech. *The affidavits for the defendants in rebuttal do not attempt to deny this.*

It cannot be a departure from Mr. Bell's invention, nor relieve the defendants from the charge of infringement, that they have changed one part of it by removing a magneto receiver and replacing it by the condenser receiver, which had long been known to be a substitute for it in the office of converting electrical variations into sound waves.

The opinions expressed and the facts stated by Prof. Cross, Prof. Wright, Mr. d'Infréville, together with the quotations given from other writers, — one of whom, Prof. S. P. Thompson, is an electrician of authority, — and the quotations from the published statements of Mr. Dolbear himself, show that this is what the defendants have done. (See Cross, p. 37.)

It is true that the defendants' condenser is not identical in form with those of Wright and Varley; they say that theirs is more efficient. Suppose this to be true: still they have only improved it in order to make it produce better, and by the same kind of operation, the same result which it already produced with practical efficiency.

The defendants in their first affidavits seemed to assert that the sounds produced by Dr. Wright and Mr. Varley were due to disruptive discharges, bursting the condenser, and not to induction and attraction. But the foregoing passages leave it clear that in all cases it was induction and attraction. The defendants' affidavits in rebuttal do not attempt to repeat their somewhat vague remarks in this particular.

Dolbear alleges that Wright used " molecular vibrations " and that the defendants use " mass vibrations " of the plates; this is a mere question of an unessential variation in degree. (See Cross, affidavit in reply, pp. 39–42.)

No one had used a condenser to reproduce articulation before the date of Mr. Bell's patent: what is the value of this fact?

The paragraph on p. 5 of Mr. Dolbear's affidavit, among many misstatements, contains an assertion to this effect which it may be inferred that the defendants consider material.

It is certainly true that before Mr. Bell's time no man had used a condenser for the receiver of a speaking telephone; it is true that no man knew by actual trial what effect Mr. Bell's articulating undulations would have on Varley's condenser receiver, for the simple reason that the speaking telephone and articulating undulations had never entered into any man's conception or experience before Mr. Bell's invention of them. In those systems which had occasion to translate into sound waves such electrical variations as they possessed, the magneto receiver and the condenser receiver had been used as equivalents. Mr. Bell improved the magneto receiver to better fit it for his more delicate work; upon the question of a change in his apparatus which shall take it outside his patent they are equivalents, even though the condenser receiver should need to be improved in form to enable it to give *valuable* results in the more delicate apparatus. For if the law on the subject of equivalents were otherwise, and applied to this case, then it would follow that the inventor of an entirely new thing could not claim its benefits, or that the broader and more entirely novel was his invention, the more easy for an infringer to appropriate the substance by changing the form, because nothing could have been known as *the equivalent in a particular machine* before that machine was known. They were however known as equivalent in the apparatus which came nearest to the telephone.

It needed only a trial of the Varley or Wright condensor, with electrical undulations as distinguished from electrical intermittences, to produce corresponding sounds. The fact that the sounds were due to motion was known. The fact that the attraction (which causes the motion) varied with the electrification was well known. Mr. Pope says (p. 22): —

> "It was well known prior to the date of Bell's patent that the direct attractive force exerted by one body upon another is in proportion to the difference in electric potential existing between them."

This was used in that well-known instrument, the electrometer. (See Prof. Cross's affidavit in reply, p. 17.) In this instrument one plate was electrified to any convenient potential, and the attraction measured by a counterbalancing weight. Then the electricity to be measured was poured in, and the increased attraction was weighed. This apparatus, which measured the difference in attraction between that due to one artificial potential and that to another artificial potential, replaced the earlier instruments which measured the difference between an artificial potential and neutrality.

Thus, for the purpose of producing sensible variations of attraction and motion, the employment of undulations instead of intermittences involved no principle and no kind of action not well known. The conception that such slight causes as are present in the telephone could produce practically audible effects with any receiver did perhaps involve what Sir William Thomson, referring to Bell's work, called intellectual "hardihood"; but Mr. Bell's invention itself taught this. It may properly be said, therefore, that the condenser was known as the equivalent of the magneto receiver for the electrical production of sound.

But, in truth, the doctrine of known mechanical equivalents has no bearing on this case.

LAWFUL SCOPE OF MR. BELL'S CLAIM FOR HIS APPARATUS.

Mr. Bell's patent, considering only so much of Claim 5 as is for an "apparatus," is not for an improvement whereby an old machine is enabled to better accomplish the same kind of a result produced before.

The apparatus is generically new in kind, its principle and mode of operation are new in kind, and its consequent result is new in kind. Now in such a case, no change which so far preserves the original features that the improved machine, by means of the retained identity and similarity, produces the same new result, by the same mode of operation as a whole, can relieve from the charge of infringement.

The speaking telephone requires two persons to operate it; and it cannot be denied that if one infringes, the other is a participant in the offence. With any of the forms Figs. 4 to 11 on p. 28, *supra*, it is certain that the speaker at T and the listener at the magneto receiver M infringe. It is said that the one who at the same time listens at the condenser receiver, and to whose ear the same utterances of the speaker are transmitted, does not infringe; but what is the condition of the speaker? Is he two single gentlemen rolled into one, — an infringer and a non-infringer at once? If the listener at M should put his telephone down for an instant and the speaker go on, and the listener at C hear all the same, would the speaker unknowingly cease to infringe, and again unwittingly begin to infringe when the listener at M began to hear?

If Mr. Bell's only invention were the receiver M, this might be; but not when the whole apparatus was of Mr. Bell.

SUMMARY OF THE FACTS.

Prof. Cross in his affidavit in reply thus sums up the conclusions (p. 4): —

> "It is thus apparent from the statements in the defendents' affidavits that there is no essential difference in the apparatus except in that portion which consists of the receiver; and that in the operation of the apparatus as a whole, and in the electrical phenomena which cause or accompany the transmission of speech, there can be no essential difference, unless it be such as is due to or compelled by the difference in the receivers. The facts which are common to both in construction and in operation are essential to the one result which both produce, and did not exist in the operation of any apparatus anterior to Mr. Bell's patent. I am, therefore, of the opinion that, without reference to other similarities or dissimilarities, the fifth claim of Mr. Bell's patent 174,465 is infringed by the use of the Dolbear apparatus. The employment of electrical variations or 'electrical undulations, similar in form to the sound waves' to which those variations were due, originated with Mr. Bell, was first directed by him, enabled him for the first time to transmit speech, and is precisely that which is claimed as novel in the fifth claim; the Dolbear apparatus transmits speech by employing them and causes them by the action of the voice on the transmitter."

Having thus stated that such a change as they claim to have made in a subordinate part of the apparatus does not change the identity of the apparatus as a whole with regard to the use of Mr. Bell's invention, he proceeds to show that the change in the receiver extends to merely one part of that instrument (p. 5): —

> "Considering the phenomena which take place in the operation of the receiver, I find that the only difference which is stated is, that in one case the electrical variations of special form which are caused at the receiving station by the operation of the transmitter and the electrical conductivity of the line wire serve to vary the attractive power between the core of an electro-magnet and a plate, and in the other these 'electrical variations' are caused to vary the attractive power between a mass of metal and a plate. In both cases, however, the fact is, and it is essential, that the variations in attraction (and consequent motion) do and must correspond to the 'electrical variations' which cause them."

This is substantially a repetition of what was in his first affidavit (*v.* p. 30, *supra*).

He stated, in the language already quoted (pp. 23, 32, *supra*), that the change did not involve the employment of any newly discovered principle or property of matter or of electricity.

And finally he showed that it consisted at most, in a slight, a possibly advantageous, but not essential, modification of the old condenser, which may have improved, but did not change, the character of its operation, and that the old condenser already possessed the capacity to reproduce speech when the electrical forces to which it had previously been exposed were compelled to vary in accordance with that new rule of variation, the discovery and application of which was the most characteristic part of Mr. Bell's invention.

THE LAW OF THE CASE.

Upon this state of facts the question arises whether the defendants infringe Claim 5 of Mr. Bell's patent 174,465.

> " *Claim* 5. The method of and apparatus for transmitting vocal or other sounds telegraphically by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

This is to be read as two claims. One is for the "method of transmitting," etc., and this is for an "apparatus for transmitting,"etc.

Two inventions connected in their design and operation may be included in one patent. *Hogg* v. *Emerson*, 11 How. 587.

The question is whether either of these claims can be infringed by the use of an apparatus which differs only within the limits we have described.

It is worth while to remember the temper in which the courts have approached other great inventions.

In *Boulton & Watt* v. *Bull*, Carpmael, 137, Mr. Justice BULLER said : " Few men possess more ingenuity or have greater merit with the public than the plaintiffs on this record ; and if their patent can be sustained in point of law, no man ought to envy them the profits and advantages arising from it."

Howe v. *Underwood*, 1 Fish, 163, SPRAGUE, J. : "For all the benefits conferred upon the public by the introduction of the sewing machine the public are indebted to Howe ; upon that there is no question. . . . No other person has given to the public this invention."

Rule for Ascertaining Infringement.

In *Howe* v. *Morton*, 1 Fisher, 588 (quoted p. 64 *infra*), SPRAGUE, J., stated the test: "The inquiry is, what is there in common between the defendants' machines and the Howe machine which is not in common between the Howe machine and the prior ones? . . . No matter what the diversities are, or what additions to or modifications of Howe's original invention have been made by the defendants, if these new improvements *are ingrafted upon Howe's invention* secured to him by his patent; if they have taken what belongs to Howe they have infringed, although with the improvements the machine may be much more useful than it would be without them. This is a well-known principle of patent law."

Goodyear v. *Day*, 2 Wall. Jr., GRIER, J.: "Every unsuccessful experimenter who did or did not come very near making the discovery now claims it. *Every one who can invent an improvement* or vary its form claims a right to pirate the original discovery."

It is clear (whether the defendants use *all* that Mr. Bell invented or not) that they use as the most important and essential part of the means and operation by which they transmit speech the essential and the most characteristic part of that which "was not in common between Mr. Bell's work and that which had preceded it." Now no case can be found in which the courts have permitted this. No court has yet permitted a patent at the same time to be availed of and defied.

The individual judgment of the writers of this brief is that the claim for the apparatus, so far as this case is concerned, is as broad as the claim for the method. The gist of the invention is the new mode of operation exhibited in the action of the apparatus *as a whole*. An apparatus which transmits speech by employing *as a whole* a material and substantial part of that novel mode of operation is substantially and as a whole the same apparatus.

A Patent for a Method and its Scope.

Nevertheless the employment of the words "method," "art," etc. in a claim show beyond criticism that the Commissioner of Patents meant to grant a broad patent, not confined to the specific form or character of mechanism shown.

Neilson's Hot-Blast Patent. — The first important direct discussion on this topic grew out of Neilson's hot-blast patent. Neilson discovered that if the air which is blown into a furnace were heated before it reached the furnace, the fuel in the latter would no longer have to perform the work of heating the air, and could expend all its energy on the ore or iron. For this purpose he caused the air to pass through a heated vessel before it reached the furnace; whereupon, to use the language of the charge to the jury, it "acquired the agent which he intends to act — heat in the blast, instead of a cold blast.' Passing a heated blast into the furnace "is the agent I mean to use in order to produce heat in the furnace." To utilize this discovery he employed an apparatus of three parts: a blower, a furnace, and a heated receptacle through which the air passed before it reached the furnace.

The patent was for "an improved application of air" in making iron. It was litigated from 1839 to about 1845. It came before the Court of Session in Scotland, before the House of Lords, and before the Court of Exchequer, and their various cases are reported in *Webster's Patent Cases*, vol. 1. The modern phraseology of "an art," "a process," "a method" was not then in vogue, and we have not observed these words in the report. The defendants' apparatus contained a blower, a heating receptacle through which the air passed and a furnace. The most important of the three, the heater, was, as a structure, very different from and very much better than anything conceived of by the patentee; but the general purpose and effect of the one apparatus as a whole was the same as that of the other; each of the three subordinate instruments of the patentee found in the defendants' apparatus a device which performed the same subordinate function, so the Court held that the defendants infringed. It was urged that this broad construction made it a patent for a "principle." It is a fact that no man has been able to attain Neilson's results in a blast furnace without blowing in hot air; and it is a matter of physical necessity that this cannot be done unless the air be artificially heated between the general atmosphere whence it is taken and the furnace where it is to act; so that his patent was practically as controlling as if for a principle.

Charge to the jury, *Webster*, p. 685: "Hence you may generally claim the mode of carrying the principle into effect by mechanical contrivance, so that any sort of apparatus, applied in the way stated, will more or less produce the benefit, and you are not tied down to any form.

"The question is not a comparison between No. 7 (the defendants' heating arrangement) and any particular vessel, but an inquiry whether No. 7 is not a contrivance to heat the air under blast at the stage proposed, and for the purpose stated in the specification, and thereby substantially the patent apparatus. If that is in your opinion its character, then I state to you in law, that the infringement is proved."

In the House of Lords, *Webster*, p. 715, Lord CAMPBELL: "After the construction put upon it by the learned judges of the Court of Exchequer, sanctioned by the high authority of my noble and learned friend now upon the Woolsack, when presiding in the Court of Chancery, I think the patent must be taken to extend to all machines, of whatever construction, whereby the air is heated intermediately between the blowing apparatus and the blast furnace. That being so, the learned judge was perfectly justified in telling the jury that *it was unnecessary for them to compare one apparatus with another*, because confessedly that system of conduit pipes was a mode of heating air by an intermediate vessel between the blowing apparatus and the blast furnace, and therefore it was an infraction of the patent."

McClury v. *Kingsland*, 1 How. 202, was before the Supreme Court at the same time that the Neilson case was before the House of Lords (early in 1843). In casting iron rolls it is important that the surface should be free from impurities. Harley discovered that if the tubes or "gates" through which the melted iron entered the mould were so directed as to enter substantially at a tangent to the cylinder, the molten iron would thereby receive the rotating motion of a whirlpool, whereby its heavier and better parts would go to the exterior and the dross and lighter parts be kept at the centre. "This was the thing patented, consisting solely in changing the direction of the tube which conveyed the metal to the mould from a horizontal or perpendicular position to an angular one. It produced the desired effect and was highly useful." The discussion on the validity of the patent was confined to the court below; but the Supreme Court found no difficulty with it.

Similar questions next came before the Supreme Court in 1852 and in 1853 (14 and 15 How.).

Le Roy v. *Tatham*, 14 How. 156. The Hansons discovered that lead which had been melted and had cooled enough to become just "set" could by pressure be forced through slits and dies, and, while under the influence of that heat and extreme pressure in a close vessel, would reunite perfectly, and they constructed a machine in which they made lead pipe by employing this property. The patent was granted March 29, 1841, before the foregoing decisions. It contained only a claim for a mechanical combination.

"What we do claim as our invention and desire to secure is the combination of the following parts above described, to wit: the core, and bridge or guide piece, with the cylinder, the piston, the chamber and the die when used to form pipes of metal under heat and pressure, in the manner set forth, or in any other manner substantially the same."

The court was composed of eight judges; CURTIS, J., did not sit; the majority opinion was by McLEAN, TANEY, CATRON and DANIEL, J.J.

The dissenting opinion was by NELSON, WAYNE and GRIER, J.J. The majority and minority both approved the doctrine of the Neilson case; and the opinion of the majority said in discussing that case: "the test of infringement is whether the defendants have used substantially the same process to produce the same result."

The majority opinion also contained the following (p. 175):—

"Nor can an exclusive right exist to a new power should one be discovered in addition to one already known. Through the agency of machinery a new steam power may be said to have been generated. But no one can appropriate this power exclusively to himself under the patent law. The same may be said of electricity and of any other power in nature which is alike open to all, and may be applied to useful purposes by the use of machinery. In all such cases the processes used to extract, modify and concentrate natural agencies constitute the invention. The elements of the power exist; the invention is not in discovering them but in applying them to useful objects. Whether the machinery used be novel, or consist of a new combination of parts known, the right of the inventor is secured against all who use the same mechanical power or one that shall be substantially the same."

Observe that the Court does not limit the invention to the use of the *same* mechanism to modify such a natural agency as electricity, or to the use of the *same* mechanism to employ the power due to such modification.

Thus the whole Court concurred that a process worked by machinery availing itself of such a natural agency as electricity might be patented in such a case if the requisite novelty existed, and differed merely as to the construction of the claim before them. The majority held that its language expressly limited the patent to the mechanical combination.

> "But we must look to the claim of the invention stated in their application by the patentees. . . . The patentees have founded their claim on this specification, and they can neither modify nor abandon it in whole or in part. . . . The question whether the newly developed property of lead, used in the formation of pipes, might have been patented if claimed as developed, without the invention of machinery, was not in the case."

The minority held that it was possible to construe the claim to be more nearly coextensive with the invention.

The decision was "that the novelty of the combination of the machinery specifically claimed by the patentees as their invention was a material fact for the jury."

Few more valuable discussions of the general topic can be found than the dissenting opinion drawn by NELSON, J.; fragmentary quotations from it would give no idea of its breadth and soundness.

O'Reilly v. *Morse*, 15 How. 62. Morse's telegraph patents. The case was decided in 1853 but was argued in 1852. CURTIS, J., did not sit in it. NELSON, WAYNE and GRIER, J.J., dissented from those parts of the opinion which seemed to deny the rights actually claimed in the suit by the patentee. The difference between the majority and the minority of the court did not really turn upon any question of principle, but upon the construction of the language of the eighth claim. The majority were of opinion that its meaning was very broad and very vague, and thus attempted to include more than the law would permit. The minority were disposed to give it a more definite meaning and thus uphold it.

It is especially necessary in studying the opinion of the majority in a series of cases where the dissent was by such judges as NELSON, who wrote the dissenting opinion in *LeRoy* v. *Tatham*, and GRIER, who wrote it in *O'Reilly* v. *Morse*, and WAYNE, who concurred, to remember the admonition about *dicta*, and illustrations which the Supreme Court gave by the mouth of MARSHALL, C. J., in *Cohens* v. *Virginia*, 6 Wheat. 399, and by the mouth of CURTIS, J., in *Carroll* v. *Carroll*, 16 How. 287.

In the telegraph case the court unanimously decided that the first seven claims of the reissued patent were valid. That included Claim 5, which was for the dot-and-dash alphabet; it was not limited to the particular combination of dots, dashes and spaces shown, but was in effect a claim for signalling letters, words and sentences by breaking up the current of a battery into a measured and recognizable succession of longs and shorts.

Inasmuch as that claim is good, there can be no possible reason why the peculiar and novel modifications of current first conceived of and used by Mr. Bell, and which produce the novel signals of his apparatus, are not as fit a subject of claim as Morse's modification of the current by breaking it into longs and shorts. The invention by Mr. Bell of his electric alphabet of articulation is certainly the more brilliant of the two.

The court unanimously affirmed the doctrines of the Neilson case, and TANEY, C. J., restated them in the new nomenclature which had been brought to notice chiefly by the opinion of Judge Grier in the Goodyear cases, and the opinion of Judge Nelson in the lead-pipe case, using the words "method" and "process."

These words are not found in the Patent Acts, but the courts had perceived that among the inventions which contributed most to "the progress of the useful arts" there were some which did not consist in a chemical process, and which did consist in something more than a mere combination of mechanism. The Patent Act enumerated "a new art" and "a new improvement in an art" as distinguished from a machine, a manufacture or a composition of matter as equally the proper subject matter of a patent, and had coupled with the words "invention thereof" the words "discovery thereof," the latter taken from the Constitution. In the lead-pipe case, referring to electricity and other powers to be applied "by the use of machinery" (and thus not restricting the rule to chemical processes), they say "in all such cases the processes used to modify . . . natural agencies constitute the invention."

In reading the language presently to be quoted, in which the majority of the court expressed the gist of their opinion, it will be observed that they carefully include a "process" and a "method" as the proper subject matter of a patent. They enunciate this proposition, not with reference to a chemical process, but with reference to a telegraphic apparatus in which that natural agent, electricity, is to be modified by mechanism at one end, and is to be operative by means of mechanism at the other.

They are further careful to state that the defendant's mechanism may infringe, though they do not copy the whole of the mechanism, nor employ the whole of the process of the patent; that changes are not material upon the question of infringement unless it appear that the defendant has employed a "mode" of producing the result" without using *any part of the process* or combination."

The eighth claim of Morse's reissued patent was as follows: —

"Eighth. I do not propose to limit myself to the specific machinery or parts of machinery described in the foregoing specifications and claims, the essence of my invention being the use of the motive power of the electric or galvanic current, which I call electro-magnetism, however developed, for making or printing intelligible characters, letters or signs at any distance, being a new application of that power of which I claim to be the first inventor or discoverer."

Having recited this, the Court say (p. 112): —

"It is impossible to misunderstand the extent of this claim. He claims the exclusive right to every improvement where the motive power is the electric or galvanic current and the result is the marking or printing intelligible characters, signs or letters at a distance. If this claim can be maintained, *it matters not by what process* or machinery the result is accomplished. For aught that we now know, some future inventor, in the onward march of science, may discover a mode of writing or printing at a distance by means of the electric or galvanic current *without using any part of the process* or combination set forth in the plaintiffs' specification."

The Court then referred to the Neilson case in the Exchequer (8 M. & W. 806), quoted with approval from Baron Parke's opinion, and proceeded (p. 116): —

"Neilson's invention consisted in interposing a heated receptacle between the blower and the furnace, and by this means heating the air after it left the blower and before it was thrown into the fire. Whoever therefore used this *method* of throwing hot air into the furnace used the process he had invented. . . . His patent was supported because he had invented a mechanical apparatus by which a current of hot air instead of cold could be thrown in. And this *new method* was protected by his patent. The interposition of a heated rectangle in any form was the novelty he invented."

The opinion then refers to *LeRoy* v. *Tatham*, and says of it (p. 118): —

"The Court held that he was not entitled to a patent for this newly discovered principle or quality in lead, and that such a discovery was not patentable; but that he was entitled to a patent for the new process or method in the art of making lead pipe, which this discovery enabled him to invent and employ."

Now, considering that all these cases were under advisement at the same time, it is clear that in the opinion of the Court if the claim in the lead-pipe case had been, not for a mere mechanical combination, but — in the language of Mr. Bell's claim — for a "*method*," the defendant, using an entirely different kind of machinery, would have been held as an infringer if an essential part of the art of making lead pipe as practised by him rested upon the employment of that "newly discovered principle."

The consideration of these authorities however has hardly more than a historic interest since the decision of the Supreme Court in *Tilghman* v. *Proctor*, 102 U. S. 707, and the decision of this court on Mr. Bell's patent in *American Bell Telephone Co.* v. *Spencer*.

In *Tilghman* v. *Proctor*, 102 U. S. 707, the whole ground was gone over, and, particularly on p. 728, the Court said that it was enough for the patent to describe the process and one practical mode in which it may be applied; and that whoever used that process infringed, although he used it by means of mechanism newly invented and patentable as such, or although he had actually modified and improved the process. "Suppose this be so, as before said, the introduction of an improvement gives no title to use the primary invention upon which the improvement is based." "In either case, the process of Tilghman, modified or unmodified by the supposed improvement, *underlies the operation performed in the defendants' boilers*."

Roberts v. *Dickey*, 4 Fish. 533, 1 O. G. p. 4 (1872), STRONG, J.: "Having thus described the art or method of securing the desired result, the patentee announced his claim to be, 'The above-described method of increasing the productiveness of oil wells by causing an explosion of gunpowder or its equivalent, substantially as above described.' . . . That the art or method of operation does work out beneficial results . . . is very satisfactorily established. . . . In fact it has proved a great public benefit. . . . As might have been expected, since the trials of the complainant's invention have demonstrated its usefulness, repeated attempts have been made by others to effect the same results by similar processes. This is the common fate of meritorious inventors.

"Now that such an invention, if it was novel, was a proper subject for a patent, hardly admits of question. It was a new and useful art; it was a process combining instrumentalities before known, but not employed together to accomplish a new and useful result. It is not to be doubted that a novel process or method of operation that amounts to a successful application of known things to a practical use is patentable as an art. . . . Roberts devised a mode of putting to practical account a geological truth, and if the means he devised were novel, if the process was the product of invention and was useful, it was a proper subject for a patent. The patent is not obnoxious to the objection successfully made against the eighth claim of the Morse patent in O'Reilly *v.* Morse, 15 How 62. That was a claim for the use of the motive power of the electric or galvanic current, however developed, for making or printing intelligible characters, signs or letters at any distance. It was therefore a claim for a principle, — a natural law, — and not for any particular method of applying it."

It will be observed that this patent was not for a chemical process. It consisted in exploding a torpedo of a known form in a particular part of an oil well sufficiently full of water or other liquid for the liquid above the torpedo to serve as a tamping. It was a method or process wrought by mechanical means; and the patent did not lie in the construction of the instrument, nor in the devices used for operating. On the contrary, the Court held that they were all old. What was new, however, was his method of increasing the productiveness of oil wells, and which consisted in employing known instrumentalities in a manner which his thought and study had enabled him to discover; that consituted his invention; it was patentable to him and forbidden to others.

R. R. Co. v. *Sayles*, 97 U. S. 556: "Being sought by many minds, it is not wonderful that it was developed in *different* and independent forms, all original and all bearing a somewhat general resemblance to each other. In such cases, if one inventor precedes all the rest and strikes out something which includes and underlies all that they produce, he acquires a monopoly, and subjects them to tribute."

Now Mr. Bell does not claim the application of the motive power of electricity to transmit speech; he claims his method for doing it, and his claim states that which constitutes both the gist and the greatest novelty of his work. If this claim practically covers the transmission of speech, it is not because it would cover methods to be invented by others, but because no one has, or perhaps no one will invent any other.

Bell v. *Gray*, 15 O. G. 778. The Commissioner of Patents in March, 1879, had to consider the scope of Mr. Bell's invention and claim, and decided in the sense we now assert. To that controversy the defendant Dolbear was a party. The Commissioner said: —

> "To grant to the inventor the exclusive use of the method only when accomplished by the particular means devised by himself, would be to give to the discoverer of the 'soul of the invention' no advantage over the mere inventor of devices for carrying the essential principle of the invention into effect. Indeed this rule practically carried out would in many cases give to mere camp followers all the fruits of great victories over the forces of nature.
>
> "The true doctrine seems to be that the discoverer of a principle who first devises a method for carrying the principle into effect, and first invents or combines means to accomplish the several steps in that method, is entitled to the exclusive use of the method itself and also of the means by him invented or combined for its practical execution; and that later inventors who devised different and not equivalent means for accomplishing the several steps of the method are entitled only to the patents for improvements upon the method or means of the first inventor, subject to his paramount right to the method itself."

The Defendants copy Mr. Bell's Apparatus as well as his Method.

Mr. Bell's fifth claim is also a claim for an apparatus.

The prohibition of the statute is not in terms against "copying" the patentee's machine; it is found in the grant to the patentee of the exclusive right to "use the invention." It is common to speak of the machines in case of infringement as "substantially the same." But this must always be understood to mean that both are substantially the same, in this, that both embrace the invention in question. For the second machine may contain newly invented additions or alterations, which in themselves may be patentable as improvements, and still as a whole it may infringe.

The two cases of *Howe* v. *Underwood* and *Winans* v. *Denmead* contain perhaps the clearest statement of the doctrine. The invention is to be ascertained by comparing the point reached by the patentee with what existed before; the difference constitutes his invention; then you are to ascertain whether this step forward in the art is availed of in the defendant's machine to enable it to accomplish its work and to give to it, in part, at least, its capacity and value.

In making this inquiry, you are not to be stopped by the fact that the defendant has altered or improved; you are not to confine yourself to the form, nor to the subordinate parts, but are to consider whether that mode of operation which the patentee introduced is availed of by the defendant to attain his result.

The law contemplates that one man will invent an art or machine, and another "a new and useful improvement thereof." A course of decisions which left the improver free from the claims of the originator, and thus practically deprived the orignator of reward unless he concealed his invention until he had attained all possible perfection in its application, would not stimulate improvement; it would simply stop all progress.

To ascertain what substantially constitutes Mr. Bell's invention, the law requires the Court not only to understand what is described in the patent, but to know what has preceded it.

For a machine, every device in which shall be different from anything which has preceded it, may be the first ever constructed for the general purpose designed; *e. g.*, it may have been the first which undertook to sew; or the work of the inventor may have been to examine an existing sewing machine, and to substitute for each of its parts something new and better adapted to perform the precise function of the part replaced. In either case the law will adjudge to the inventor a valid patent; but the judgment of the law in passing between the inventor and an alleged infringer will not be the same in the two cases.

The patentee's invention will not be the same in the two cases, for that is measured, not by the point reached, but by the distance passed over from what has been reached before.

In the one case, a new machine has been contributed to the useful arts; in the other, an improvement has been made in a machine which those arts already possessed.

The difference between a generic invention — the invention of a new genus of machine — and the invention of an improvement exists in the nature of things as a great difference; and the patent law would be ill adapted to mankind if it did not recognize it as a fundamental. It always has so recognized it: The phrases "new and useful art, machine," etc., or any "new and useful improvement on any art, machine," etc., have been used in all the patent acts (see Act of 1793, Sect. 1; 1836, Sect. 6) to describe the various kinds of inventions for which patents might be granted. The distinction in law which the courts have based upon this distinction in fact may be indicated generally as follows: if the invention be of a new method or new kind of machine, then whoever uses that method or genus of machine uses the invention and infringes, though he has changed the mechanism employed by the addition or substitution of devices which are novel and patentable; but if the invention consists merely in the substitution of a newly invented part for an old one, without change in the general character and function of the machine as a whole, then a second inventor (or improver) has an equal right to substitute a different part invented by him in place of that which was found in the old machine from which both started.

Whether a particular invention falls within one class or the other sometimes presents difficulties of fact, and the distinction itself has some application to inventions of different grades. Thus, in the sense of the rule, the first invention of a machine to cut the grass by the now well-known knives would be a generic invention; the addition of a new feature to it, which enabled it to cut and handle grain, would probably, *quoad* the special and limited subject matter, be a generic invention, because it would give the power to do a new and substantially different thing, yet as a whole this machine would infringe the first; while taking out a device or sub-combination which performed one function in the whole apparatus, and substituting another, newly invented, which operated more effectually to perform the same subordinate work, would be a mere invention of an improvement in the narrowest sense.

In the patent law there is no such thing as abstract identity: as regards one invention the law may consider two machines substantially the same; as regards a narrower invention it may consider them substantially different.

It is generally true that the broader the scope of the invention and the greater the revolution it introduces in the arts, the greater are the patentable changes which can be made in the devices embodying it without loss of its substantial identity; or in other words, the greater is the variety of improvements which invention can make in it without destroying its essential character. This is true in law because it is true in fact. It was well recognized in the Neilson case and many others.

The whole legal history of the sewing machine, the reaping machine, the manufacture of india rubber and many other invented industries has been based upon these doctrines, which have often been judicially stated and acted upon.

Sanford v. *Merrimack Hat Company*, 10 Gazette, 466, CLIFFORD, J., "Patentable inventions pertaining to machines may be divided into four classes: *First*, Entire machines, as a car for a railway or a sewing machine. *Second*, Separate devices of a machine, as the coulter of a plough or the divider of a reaping machine. *Third*, New devices of a machine in combination with old elements, all embraced in one claim, or with separate claims for what is new, together with a claim for the new combination of all the elements. *Fourth*, Devices or elements of a machine in combination where all the devices or elements are old."

Applying this rule to a contest between Howe's patent and a sewing machine in which every or nearly every subordinate function was performed by devices not only different from those of Howe, but novel and patented as such, he said in *Howe* v. *Williams*, 2 Fish. 401, that Howe's invention was not a combination in the technical sense, but that this claim was for an "organized machine as an existing whole, and not merely for some or all of these separate devices of which it is composed, or for some or all of those devices as a mere technical combination"; and he rested a decree for the complainant on the first claim, which was for the organized machine as an existing whole, though the defendant's machine has no shuttle, no baster plate and no curved needle, which were, and were named in that claim as three of the most essential and operative parts of the plaintiff's machine. But the defendant had replaced each of them by devices which though newly invented, yet performed *in the whole machine and towards the final result* the same functions as the parts which they replaced. The new character of these devices, considered *per se* is stated in *Potter* v. *Holland*, 1 Fish. 391. (Wilson's four-motion feed.)

The authorities on this subject are placed in the appendix, p. 60.

Substantial Identity of the two Forms of Apparatus.

No man will doubt that Mr. Bell constructed an apparatus generically new as a whole; that its most valuable novelty lay in its peculiar mode of operation; and that the great novelty in its mode of operation was that in it the voice caused a peculiar sequence of electrical undulations, the sounds produced by which, owing to the peculiar form of the undulations, differed from any ever produced by any other apparatus. This same novelty is the soul of their apparatus. Each part of ours has its counterpart in theirs. The part which they substitute for the original part has the same capability as the original, and is employed because it has the same capability. They do not even remove a whole subordinate instrument, but they lead the conducting wire to a block of iron which thereby attracts a sonorous diaphragm instead of leading it to a coil and core which thereby attract the same sonorous diaphragm. The alteration moreover consists in the employment of one known way in which the electricity may manifest itself to produce sound instead of another known way. But the character of the sound which gives its sole value to the apparatus is in both due to that which they copy from Mr. Bell, to wit, the similarity in form between the electrical variations and the aerial variations. Their apparatus is, therefore, in the sense of the law, substantially the same as ours.

MR. BELL'S CLAIM IS NOT UNLAWFULLY BROAD.

Is there anything which impairs the validity, of the claim granted to Mr. Bell for this method?

The defendants' affidavits intimate one ground, which they apparently propose to urge.

Prof. Trowbridge says that speech cannot be transmitted unless the electrical variations on the line wire are similar in form to the sound waves (p. 27, passage already quoted). Mr. Dolbear says (p. 5): —

> "There must be electrical variations of some sort on the wire, and the electrical variations (whatever they are) must correspond with those which the voice has produced in the air; unless those things are done, the use of electricity for the purpose of transmitting speech is physically impossible."

Mr. Bell, however, went further than this. He employed the sound waves themselves to produce these electrical undulations.

Mr. Dolbear's affidavit also goes a little further; at the top of p. 7 he appears to assert that it is impossible that speech should be transmitted unless the spoken words are employed to produce the undulations which are to transmit them; he says: —

> "It is a truism that the electric vibrations must conform to the air vibrations which produce them, if the electric vibrations are to be used to produce air vibrations like the first. . . . So much is inevitable, and due not to invention, but to the physical laws involved."

A most extraordinary exhibition of the confusion of ideas.

If it be a truism *now*, no one knew of it or used it until Mr. Bell discovered the fact and pointed it out. What invention or machine does not owe its operation "to the physical laws involved"? and must it not be said of all inventions or machines that, given the structure and the conditions produced by the inventor, the result is "inevitable"?

The argument of this affiant seems to be: True it is that Mr. Bell has disclosed a method which no one knew before, and has made an apparatus embodying a principle or mode of operation which no one knew of before, and has thereby accomplished a novel result. He has taken a patent for that method and that apparatus. If he or some one can show us other and different methods, his patent is good; but if no one can find any other, then his patent is bad. Suppose some one discovered another method when his patent was five years old, what would be its fate?

Or, to state it otherwise, the would-be pirate will copy what he pleases, and, when charged with theft, will say, "I only copied those novelties which were the soul of the invention, and which I must have if I would obtain the results your method first enabled the world to attain. I have copied what I needed to enable me to reap the advantages of your invention, and discarded those parts which I could replace."

Is that a defence?

If there be another method, they seem to imply that the patent would be good. Suppose there were two methods possible, and Mr. Bell had discovered both and patented both, or suppose he had patented one and some one else had patented another.

To a proposition which involves only a confusion of legal ideas, a *reductio ad absurdum* is perhaps the best answer.

Morse's eighth claim was bad because it sought to monopolize future and unknown methods which would not "use *any part of the process* or combination set forth in the plaintiff's specification." Mr. Bell seeks to monopolize the method specifically set forth in his claim.

Morse sought to hold all who accomplished similar results without any indebtedness to what he had taught. Mr. Bell wishes to hold those who avail themselves of what he discovered and disclosed.

Morse sought to monopolize results by excluding all other methods. The defendants assert that Mr. Bell's claim would monopolize results; but if so, it is because no method except the one he first used is adequate to produce them.

Every great invention practically monopolizes results. Nothing is sewed by machinery without Howe's invention; no cloth is woven by machinery without Crompton's. We recognize one inventor of the sewing machine, one inventor of vulcanized rubber, one inventor of the telegraph, one inventor of the locomotive. The common sentiment of mankind joins with the judgment of the law in perceiving the fact that the original invention is in all the later forms. The facts given by Mr. Watson in his affidavit, pp. 78, 79, show that Mr. Bell is practically recognized as the inventor of the electric-speaking telephone. Other men have embodied it in improved forms, but he is known as the progenitor.

MR. BELL'S SECOND PATENT 186,787 IS ALSO INFRINGED.

The sixth claim is for the enclosing case, which protects the back side of the diaphragm from extraneous air vibrations, and presents in front of it the thin air space and central opening which have been universally adopted in practice.

Mr. Bell's originality in this is not denied. The advantage of the thin air space is set forth by Prof. Cross, pp. 40, 41; it is used by the defendants, and its utility is not denied. They do deny that the rear enclosure is valuable. They rest this on an extract from Mr. E. S. Renwick's deposition in the Dowd case, printed on p. 21 of defendant's affidavits in rebuttal. This, however, is met by Mr. Watson's deposition, printed on p. 74 of the complainant's affidavits in reply. Mr. Renwick's views were based on one or two purely experimental tests; Mr. Watson's on extensive practical use.

Mr. Cross added this peculiar sound box to the old condensers of Wright and others and found their performance much improved. Affidavit in reply, p. 40. The subsequent affidavits for the defence do not deny this.

The defendants cannot successfully deny the utility of a device which they find it expedient to construct and use.

Respectfully submitted by

CHAUNCEY SMITH,
JAMES J. STORROW,
for Complainants.

BOSTON, May, 1881.

APPENDIX.

The following cases discuss the question of what constitutes infringement of a patent for an apparatus new in kind and new as a whole.

Winans v. *Denmead*, 15 How. 330. The plaintiff claimed "making the body of a car in the form of a frustum of a cone, substantially as herein described, whereby," etc., and "extending the bottom of the car below the truck frame by passing," etc. For this he alleged and proved two advantages: 1. The circular shape gave him the advantage of the tensile strength of the iron. 2. The tapering shape enabled him to project part of the load between the wheels, and thus lower the centre of gravity. 3. Easy discharge of the load.

The defendant used a tapering octagon. Held that he infringed.

Curtis, J.: "In this, as in most patent cases founded on alleged improvements in machines, in order to determine what is the thing patented, it is necessary to inquire: —

"1. What is the structure or device described by the patentee as embodying his invention?

"2. What mode of operation is introduced and employed by this structure or device?

"3. What result is attained by means of this mode of operation?

"4. Does the specification or claim cover the described mode of operation by which the result is attained?

"By means of this change of form, the patentee has introduced a mode of operation not before employed in burden cars; that is to say, equal pressure in all directions, the effect of which is that the tensile strength is employed and the centre of gravity lowered and discharge facilitated.

"To change the form of an existing machine, and by means of such change to introduce and employ other mechanical principles or natural powers, or, as it is termed, a new mode of operation, and thus attain a new and useful result, is the subject of a patent. Such is the basis on which the plaintiff's patent rests.

"Its substance is a new mode of operation by means of which a new result is obtained.

"It is this new mode of operation which gives it the character of an invention and entitles the inventor to a patent; and this new mode of operation is, in view of the patent law, the thing entitled to protection.

"The patentee may and should so frame his specification of claim as to cover this new mode of operation which he has invented; and the only question in this case is whether he has done so, or whether he has restricted his claim to one particular geometrical form.

"There being evidence in the case tending to show that other forms do in fact embody the plaintiff's mode of operation, and by means of it produce the same new and useful result, the question is whether the patentee has limited his claim to one out of the several forms which thus embody his invention.

"Now, while it is undoubtedly true that the patentee may so restrict his claim as to cover less than what he invented, or may limit it to one particular form of machine, excluding all other forms, though they also embody his invention, yet such an interpretation should not be put upon his claim if it can be fairly construed otherwise."

Generally the infringer has forms and proportions not described, and not in terms claimed.

"It is only ingenious diversities of form and proportion, presenting the appearance of something unlike the thing patented, which give rise to questions: and the property of inventors would be valueless if it were enough for the defendant to say, Your improvement consisted in the change of form; you describe and claim but one form; I have not taken that, and so have not infringed. The answer is, My improvement did not consist in a change of form, but in the employment of principles or powers in a new mode of operation, embodied in a form by means of which a new or better result is produced; it was this which constituted my invention; this you have copied, changing only the form. And that answer is justly applicable to this patent.

"Undoubtedly there may be cases in which the Letters Patent do include only the particular form described and claimed. . . .

The reason why such a patent covers only one geometrical form is not that the patentee has described and claimed that form only; it is because that form only is capable of embodying his invention, and consequently if the form is not copied the invention is not used. Where form and substance are inseparable, it is enough to look at the form only. Where they are separable, where the whole substance of the invention may be copied in a different form, it is the duty of courts and juries to look through the form for the substance of the invention; for that which entitled the inventor to his patent, and which the patent was designed to secure. Where that is found there is an infringement, and it is not a defence that it is embodied in a form not described and in terms claimed by the patentee.

"Patentees sometimes add to their claims an express declaration to the effect that the claim extends to the thing patented, however its form or proportions may be varied; but this is unnecessary. The law so interprets the claim without the addition of these words.

"The exclusive right to the thing patented is not secured if the public are at liberty to make substantial copies of it, varying its form or proportions; and therefore the patentee, having described his invention and shown its principles, and claimed it in that form which most perfectly embodies it, is in contemplation of law deemed to claim every form in which his invention may be copied, unless he manifests an intention to disclaim some of those forms.

"It is not necessary that the defendant's cars should employ the plaintiff's invention to as good advantage as he employed it, or that the result should be precisely the same in degree. It must be the same in kind, and effected by the employment of his mode of operation in substance."

The invention in this case was generic in its nature. Physically, the change introduced was a change of form, and the precise form shown in the patent and specifically referred to in the claim was not copied by the defendant. One great merit of this admirable judgment is that it established the law to be that in the case of a generic invention, certainly where the patentee has written in his claim, or where the law reads there, the phrase "substantially as described," the court will ascertain what constitutes the substantial novelty and essential character of the invention in the broadest sense embodied in the apparatus described, and will decide all questions of infringement accordingly.

It was in pursuance of the same line of thought that the Supreme Court said in *Seymour* v. *Osborne,* 11 Wall. 516, that where the invention was of detail, the precise novelty must be pointed out; but that where it embraced an entire machine, it was sufficient if it appear that the claim is as extensive as the invention. In the same spirit, Mr. Justice Strong, in the Roberts torpedo cases (*supra*, p. 51), said that the phrase "substantially as described," in the claim of a patent for a generic invention, did not restrict the claim to the form shown, but on the contrary broadened it to include whatever the court found to be characteristic of the invention in the widest sense.

R. R. Co. v. *Sayles*, 97 U. S. 556. BRADLEY, J.: "Like most other inventions, that of double brakes came when in the progress of mechanical improvement it was needed; and being sought by many minds, it is not wonderful that it was developed in different and independent forms, all original and all bearing a somewhat general resemblance to each other. In such cases, if one inventor precedes all the rest and strikes out something which includes and underlies all that they produce, he acquires a monopoly and subjects them to tribute; but if the advance towards the thing desired is gradual and proceeds step by step, so that no one can claim the complete whole, then each is entitled only to the specific form of device which he produces, and every other inventor is entitled to his own specific form, so long as it differs from those of his competitors and does not include theirs. These general principles are so obvious that they need no argument or illustration to support them."

Howe v. *Morton*, 1 Fisher's Patent Cases, 588. SPRAGUE, J.: "The inquiry is, What is there in common between the defendants' machines and the Howe machine which is not in common between the Howe machine and the prior ones? or in other words, what do the defendants use that belongs to Howe? it being taken for granted that whatever is new in Howe's machine belongs to him and is secured by his patent, and it being insisted that nothing of that which is new and secure by his patent is used by the defendants in their machines. So that it is the question whether the defendants do use what belongs to Howe by his patent.

"And here I would remark that this inquiry excludes various matters which have properly enough been gone into as to the diversities between the defendants and Howe's machines.

"No matter what the diversities are, or what additions to or modifications of Howe's original invention have been made by the defendants: if these new improvements are engrafted upon Howe's invention secured to him by his patent, if they have taken what belongs to Howe, they have infringed, although with the improvements the machine may be much more useful than it would be without them. This is a well-known principle of patent law.

"We are to inquire what there is in the defendants' machines that is taken from Howe's, and this induces the necessity of a comparison in the first place between Howe's patent and what was prior, in order to determine what there is in Howe's that is novel. In examining Howe's patent, let us look in the first place at the summing up, the first claim in which as follows: —

"'The forming of the seam by carrying a thread through the cloth by means of a curved needle on the end of a vibrating arm, and the passing of a shuttle furnished with its bobbin in the manner set forth between the needle and the thread which it carries, under a combination and arrangement of parts substantially the same with that described.'"

Howe v. *Williams*, 2 Fish. 401. CLIFFORD, J.: "Howe's invention was not a combination in the technical sense, but his claim is for an organized machine as an existing whole, and not merely for some or all of the separate devices of which it is composed, or for some or all of those devices as a mere technical combination." The first claim is for the organized machine as an existing whole. The court rested its decision on this claim (p. 414). There is no shuttle in the defendants' machines. "Other devices are found there which perform the same functions and which stand in the same combination as that in which the shuttle is arranged in the plaintiff's machine." They are to be regarded as equivalents for it.

"Palpable differences are observable in the form of the devices employed, but they perform the same function, have substantially the same mode of operation, and accomplish the same result; and I am of the opinion that the devices, when considered together and viewed as a feeding apparatus, are substantially the same as the feeding apparatus in the machine of the complainant."

It had already been established in *Potter* v. *Holland* and otherwise that the feeding apparatus which superseded that of Howe was not known at the date of his patent, but contained patentable novelty; separately considered it was substantially different. Thus: —

Potter v. *Holland*, 1 Fish. 391. INGERSOLL, J.: "But it has been already shown that Wilson's new automatic feed was not to be used in conjunction with or in aid of or in addition to the old feed; that it was not merely an improvement on the old feed, but that it was independent of it, that it dispensed with it, that it discarded it, that it was an entire new device, and not something added to an old device."

McCormick v. *Talcott and Manny*, 20 How. 402. GRIER, J.: "In order to ascertain whether the divider used by defendants infringes that of the complainant, we must first inquire whether McCormick was the first to invent the machine called a divider performing the functions required, or has merely improved a known machine by some peculiar combination of mechanical devices which perform the same functions in a better manner. If he be the original inventor of the device or machine called the divider, he will have a right to treat as infringers all who make dividers operating on the same principle and performing the same functions by analogous means or equivalent combinations, even though the infringing machine may be an improvement of the original and patentable as such. But if the invention claimed be itself but an improvement on a known machine by a mere change of form or combination of parts, the patentee cannot treat another as an infringer who has improved the original machine by use of a different form or combination performing the same functions. The inventor of the first *improvement* cannot invoke the doctrine of equivalents to suppress all other improvements which are not mere colorable invasions of the first."

Waterbury Brass Co. v. *Miller*, 9 Blatch. 96. WOODRUFF, J.: "The art of spinning metal was old, but the patentee discovered that if a piece of brass be rigidly confined in a lathe, and the tool be required to follow rigidly a fixed path, a large kettle could be readily spun. The patent described a machine in which the tool was moved automatically along the path which guides provided for it. The defendants used guides, but *moved* the tool by hand. The patents were for a machine and for the product of the process.

"The defendants insist that no part of the complainants' machine was new; that that machine and all of Hayden's invention consisted of a combination of old elements; and they therefore invoke the principle, perfectly well settled and familiar, that where a patent is granted for a mere combination of old devices to produce a new result, such a patent is not infringed by one who produces the same result without using all the devices which are included in the combination patented.

"*Prouty* v. *Ruggles*, 16 Peters, 336, 341. *Vance* v. *Campbell*, 1 Black, 427. *Eames* v. *Godfrey*, 1 Wall. 78. *Byam* v. *Farr*, 1 Curtis, 1 C. C. R. 260, 265. *Foster* v. *Moore*, *id.* 279, 292. *Doubleday* v. *Bracheo*, 2 Fisher's Patent Cases, 560. *Bliss* v. *Haight*, 3 *id.* 621.

"In any proposed application of this principle, it should be borne in mind that in a certain sense nearly all new machines are but combinations of old devices; that is to say, they do or may combine frames, bolts, screws and nuts, rods and pulleys, cranks and wheels, levers and pins, nails and boards, and as the case may be, various other and more complicated devices, none of which, regarded separately or singly, are new; and yet the machine formed by the combination is new as a structure, new in its operation, and new in the effect produced. The patent in such case is not for a mere combination, under the rule above referred to; and another machine having the like construction, operation and effect, in all that constitutes the principle of the machine and the efficient means of its operation, is an infringement of the patent, notwithstanding it may be moved by a less number of wheels or be held together by a less number of clamps, screws or nails, bolts or keys, and notwithstanding drum and pulley may be substituted for cog wheels or other gear, or bolts for screws and nuts, or like changes be made in other devices employed to construct the machine. Such machine, notwithstanding such changes, is substantially the same in its patentable characteristics, and would be within the terms of the specification, 'substantially as described.'

"This is true, in my opinion, of the machines used by the defendants in their relation to the complainants' patents. They appropriate its essential features, and employ the same process to which the metal is subjected in the manufacture.

"The complainants' patent is not strictly for a combination, but rather for a machine, or a process wrought by a machine. Like all machines, it is constructed by combining elements or details. In its distinctive features, as a machine for the purposes described in the claim and as a process of making kettles, it has been copied by the defendants."

P. 100. "It embodies the principle, process and substantial means which the Hayden machine embodies, and operates substantially in the same way, though it may be less perfectly."

Tilghman v. *Morse*, 9 Blatchford, 425. BLATCHFORD, J.: "The first claim is the only one which it is proposed to consider in this case, and is as follows: The cutting, boring, grinding, dressing, engraving and pulverizing of stone, metal, glass, pottery, wood and other hard or solid substances by sand used as a projector, when the requisite velocity has been artificially given to it by any suitable means. . . . There can be no doubt of the great merit and utility of the plaintiff's invention; it has been extensively applied to practical use. The defendant in his patent disclaims having been the inventor of anything shown and described in the plaintiff's patent, and confines his claims to the mechanical arrangement of a hopper, a tube, and a cushion in combination, and to the use of the mixed compound of corundum and emery.

"The first claim of the plantiff's patent is for a process or art, and is valid. It is infringed by the defendant. There is no doubt as to the novelty and utility of such process."

This was evidently for a mechanical process.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

No. 1424.

American Bell Telephone Company et al.

v.

Albert Spencer et al.

OPINION OF THE COURT.

[June 27, 1881.]

Lowell, J.

The bill alleges an infringement of two patents, granted to Alexander Graham Bell. The defendants admit that they have infringed some valid claims of the second patent, but the plaintiffs are not content with this admission; they rely besides upon the fifth claim of the first patent, which is much more comprehensive in its scope.

Patent No. 174,465, issued to Bell, dated March 7, 1876, is entitled "Improvement in Telegraphy," and is said in the specification to consist in "the employment of a vibratory, or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line wire." The patentee mentions several advantages which may be derived by the use of this undulatory current, instead of the intermittent current, which continually makes and breaks contact, in its application to multiple telegraphy, that is, sending several messages, or strains of music, at once over the same wire; and the possibility of conveying sounds, other than musical notes. This latter application is not the most prominent in the specification; though, as often happens, it has proved to be of surpassing value. This part of the invention is shown in figure 7, of the drawings, and is thus described in the text:

> "The armature, *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg, *d*, of the electro-magnet, *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to convey sound vibrations upon the membrane. When a sound is uttered in the cone, the membrane, *a*, is set in vibration, the armature, *c*, is forced to partake of the motion, and thus electrical undulations are created upon the circuit *E*, *b*, *e*, *f*, *g*. These undulations are similar in form to the air vibrations caused by the sound; that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet, *f*, influences its armature, *h*, to copy the motions of the armature, *c*. A similar sound to that uttered in A, is then heard to proceed from L."

With the figure 7 before us, this description is readily understood. A cone of pasteboard, or other suitable material, has a membrane stretched over its smaller end; at a little distance is a piece of iron magnetized by a coil through which is passing a current of electricity. When sounds are made at the mouth of cone, A, the membrane vibrates like the drum of a human ear; and the armature, which is directly in front of the magnet, vibrates with the membrane, and its movements cause pulsations of electricity like those of the air which excited the membrane, to pass over the wire; and the wire stretches to another similar magnet and cone with its membrane and armature. The second armature and membrane take up the vibrations and make them audible by repeating them into the condensing cone, L, which translates them into vibrations of the air.

The defendants insist that the instrument represented in figure 7 will not transmit articulate speech; that this great result has been reached by Mr. Bell entirely through the improvements described in his second patent, such as the substitution of a metal plate for the stretched membrane, and some others.

The importance of the point is, that if Bell, who is admitted in this case to be the original and first inventor of any mode of transmitting speech, had not completed his method, and put it into a working form when he took his first patent, he may lose the benefit of his invention; because, in his second patent, he makes no broad claim to the method or process, but only to the improvements upon a process assumed to have been sufficiently described in his first patent.

There is some evidence that Bell's experiments with the instrument, described in figure 7, before he took out his patent, were not entirely successful; but this is now immaterial; for it is proved that the instrument will do the work, whether the inventor knew it or not, and in the mode pointed out by the specification.

The fifth claim of this patent is for

> "The method and apparatus for transmitting vocal, or other sounds, telegraphically, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal, or other sounds, substantially as set forth."

The defendants use a method and apparatus for transmitting vocal sounds, which resemble those of the plaintiffs in producing electrical undulations copied from the vibrations of a diaphragm, and sending them along a wire to a similar receiver at the other end. The specific method of producing the electrical undulations is different. It is made on the principle of the microphone, which has been very much improved since the date of the first Bell patent.

If the Bell patent were for a mere arrangement, or combination of old devices, to produce a somewhat better result in a known art, then, no doubt, a person who substituted a new element not known at the date of the patent might escape the charge of infringement. But Bell discovered a new art, — that of transmitting speech by electricity, — and has a right to hold the broadest claim for it which can be permitted in any case; not to the abstract right of sending sounds by telegraph, without any regard to means, but to all means and processes which he has both invented and claimed.

The invention is nothing less than the transfer to a wire of electrical vibrations like those which a sound has produced in the air. The claim is not so broad as the invention. It was, undoubtedly, drawn somewhat carefully in view of the decision in *O'Reilly* v. *Morse*, 15 How. 62, and covers the method and apparatus, that is, any process and any apparatus of substantially similar character to those described. The patent points out distinctly, that the undulations may be produced in other modes besides the vibration of an armature in front of a magnet; and the defendants make use of a mode not wholly unknown at that time, though much improved, in creating their undulations.

It seems to me that the defendants use both the method and the apparatus of Bell. The essential elements of the method are the production of what the patent calls undulatory vibrations of electricity to correspond with those of the air, and transmitting them to a receiving instrument capable of echoing them. Granting that the defendants' instrument for converting the vibrations of the diaphragm into vibrations of electricity is an improvement upon that of the plaintiffs, still it does the same sort of work, and does it in a mode not wholly unknown at the date of the patent; though I do not consider that material.

An apparatus made by Reis, of Germany, in 1860, and described in several publications before 1876, is relied on to limit the scope of Bell's invention. Reis appears to have been a man of learning and ingenuity. He used a membrane and electrodes for transmitting sounds, and his apparatus was well known to curious inquirers. The regret of all its admirers was, that articulate speech could not be sent and received by it. The deficiency was inherent in the principle of the machine. It can transmit electrical waves along a wire, under very favorable circumstances, not in the mode intended by the inventor, but one suggested by Bell's discovery, but it cannot transmute them into articulate sounds at the other end, because it is constucted on a false theory, and the delicacy of use required to make it perform part of the operation is fatal to its possible performance of the other part. A Bell receiver must be used to gather up the sound before the instrument can even now be adapted to a limited practical use. It was like those deaf and dumb pupils of Professor Bell, who could be taught to speak, but not to hear. That was all, but it was enough. A century of Reis would never have produced a speaking telephone by mere improvement in construction.

I am of opinion that the fifth claim of patent No. 174,465, is valid, and has been infringed.

The statute declares that if a patentee has claimed too much in any part of his patent he shall not recover costs, and it has been argued that certain claims of these patents, not relied on by the plaintiffs, are too broad. In this stage of the case the question of costs does not arise; but I may as well say, that there is not sufficient evidence in the record to enable me to find whether these claims are valid or not; and that the statute does not mean that claims not in issue should be contested for the mere purpose of settling the costs. More expense might be incurred in such a mode of trial than depended upon the main issue.

Decree for the complainants.

Circuit Court of the United States.

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE CO.

vs.

AMOS E. DOLBEAR, et al.

DEFENDANTS' BRIEF.

CAUSTEN BROWNE,
J. E. MAYNADIER, } *for Defendants.*

Circuit Court of the United States.

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE CO.

VS.

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DEFENDANTS' BRIEF.

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Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR, ET AL.

DEFENDANTS' BRIEF.

We shall submit to the court:

1. That the construction of the Bell fifth claim, as for a method of transmitting speech telegraphically, *consisting* in "causing electrical undulations similar in form to the vibrations of the air accompanying" speech, is in substance and effect a claim to *transmitting speech by electricity*, and that so constituted the patent would be void.

2. That the true construction of the fifth claim is that it covers the method described in the specification, and all other methods which are substantially the same, for producing, by the action of the voice, electrical undulations on the line wire, corresponding in form to the speech vibrations of the air, and converting such electrical undulations into vibrations of the air corresponding with the first.

3. That an essential part of the method of Bell, viz., the reconversion of electrical undulations on the line wire into sound vibrations at the receiving station, consists in converting the electrical undulations into magnetic variations which affect the vibrating body at the receiving station.

4. That this essential part of Bell's method is not practised by the defendants, nor anything substantially the same as Bell's, nor a known substitute therefor.

5. That the court did not in the Spencer case decide, and was not asked to decide, to the contrary of our third proposition, but did give to the Bell claim a construction with which that proposition is in entire harmony.

6. That, in view of the character of the questions of law and fact which are involved in this motion, the determination of them should be reserved for final hearing, and this motion for interlocutory injunction should be refused.

In his opinion in the Spencer case, Lowell J., says: "Bell discovered a new art, — that of transmitting speech by electricity, — and has a right to hold the broadest claim for it which can be permitted in any case; not to the abstract right of sending sounds by telegraph, without any regard to means, but to all means and processes which he has both invented and claimed."

" Not to the abstract right of sending *sounds* by telegraph."

Sounds here means speech; for it has never been denied that Page and Reis published modes of telegraphing *sounds*.

It is undoubtedly true that Bell, whatever may be the originality and breadth and value of his invention, cannot have a patent for *sending speech by telegraph*.

It is equally true that he cannot have a patent for doing, *no matter how*, that which, as a matter of physical necessity, attends and involves sending speech by telegraph, the physical *law* upon which it depends.

It is the *substance* of the claim, not its *phraseology*, which our law forbids.

To discern and to state what takes place when speech is telegraphed — what is the law upon which its telegraphic transmission depends — is *scientific discovery*.

And that discovery cannot be appropriated by any patent which claims, in substance and broadly, *causing those essential physical conditions of telegraphing speech to exist.*

In *O'Reilly v. Morse*, 15 *How.* 113, the claim was "the use of the motive power of the electric or galvanic current, which I call electro-magnetism, however developed, for marking or printing intelligible characters, signs or letters at any distances, — being a new application of that power of which I claim to be the first inventor or discoverer"; and it was held void.

Suppose the claim had been "the method of transmitting signals telegraphically by causing variations of the electric or galvanic current corresponding to the signal sent, and causing such variations to reproduce like signals at the receiving station"; such a claim would have been held void for the same reasons that Morse's claim was held void.

The fallacy in such a case is in confounding the *statement* of the problem and the *solution* of it.

When Bell says, "I claim the method of transmitting vocal or other sounds [articulate speech] telegraphically *by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds*," that is only the statement of the problem. When he adds, "*substantially as set forth*," that refers us to the specification to find his solution of it.

That electrical undulations shall be caused upon the line similar in form to the speech vibrations of the air, and that these electrical undulations shall in turn produce air vibrations like the first, is the *problem*. Unless it is done in *some* method, the telegraphic transmission of speech is physically impossible.

We understand that the evidence in this case shows affirmatively that the essential physical condition of telegraphing speech, the scientific law which underlies any and every possible mode of telegraphing speech, is this: that there must be produced on the line electrical variations which correspond in form with the air waves produced by speaking, and that the act of speaking must, in some way, cause these corresponding electrical variations to be set up, and that the electrical variations must, in some way, cause air waves at the receiving station like those at the transmitting station.

And we also understand that the Bell method is *now* defined by the plaintiff as consisting in *doing this thing*, no matter how; and therefore that the patent is broadly *for telegraphing speech*, — not in terms so, but so in necessary effect.

That the claim asserted for the plaintiff in the affidavits filed in this case goes to the full extent above stated is clear; but it may be attempted in argument to so construe the claim that, without making it cover broadly the telegraphic transmission of speech, it may cover a method stated *broadly enough* to include the Dolbear method.

This cannot be done. The telegraphic transmission of *speech* necessarily involves the utterance of the speech against something which in some way causes electrical vibrations to exist on the line similar in form to the speech vibrations of the air, which electrical variations cause something at the receiving station to act upon the air so as to produce air vibrations like the first.

If the claim is for *doing this*, it is for *telegraphing speech.*

If, to avoid this difficulty, we undertake to *specialize* the elements of the method, we must then put the claim upon the peculiar *way in which* he makes the utterance of speech produce the electrical undulations on the line and the peculiar *way in which* he makes those electrical undulations produce the vibrations again at the receiving end.

The claim is either generic or specific: it cannot be neither, and it cannot be both.

The plaintiff's brief in the Spencer case quotes Sir Wm. Thompson as saying that "Mr. Bell's invention *realized* the *mathematical conception* that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must *vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound.*"

This is just the special character of current variations which Mr. Bell claims the monopoly of producing by means of the sound waves.

And Sir Wm. Thompson says that it is "a mathematical conception" of what must be done — *a statement of the problem.*

Bell's affidavit in the present case says (*page* 19): "Before this time [May, 1875] I had perfectly satisfied myself ... . that *the electrical transmission of speech depended upon producing upon the line wire electrical undulations or variations which should correspond in form to the aerial vibrations which constituted the sound to be transmitted.*"

Cross's affidavit in the present case says (*page* 31) : "The method of transmitting vocal and other sounds by a constant and continuous control over the receiver, through a current which is undulatory and continuous, and not intermittent or broken, and which itself is produced or controlled by, and therefore conforms to, the motion of the transmitter actuated by sound waves, *is essential to the transmission of articulate speech.*"

The defendants' expert witnesses say the same.

Pope says (*page* 24), "Speech cannot be telegraphed at all unless electrical action of some sort is made to take place which corresponds with the mechanical action of sound waves, and which is capable of producing again a like mechanical action. *This is necessarily involved in the use of electricity for this general purpose.*"

Trowbridge says (*page* 27) : "In both the method of Dolbear and that of Bell, electrical variations corresponding in form with the air vibrations produced by the utterance of speech are set up in the line wire. *Unless this is done it is physically impossible that speech should be transmitted by electricity.*"

Farmer says (*page* 29) : "The external features of the two systems have this in common: that the speaker speaks against a vibrating body, the hearer listens near another vibrating body, and the sounds transmitted are transmitted by electricity. *And these characteristics will, in my opinion, as a matter of physical necessity, be found in any apparatus that can be or will be devised for the electric transmission of speech, however widely its principle of operation may vary from any we now know.*"

Dolbear says (*page* 7) : "*It is a truism that the electric variations must conform to the air vibrations which produce them, if the electric vibrations are to be used to produce air vibrations like the first.*"

Professor Cross takes up this statement of Dolbear's and makes it plain that the alleged infringement of the method of the 5th claim turns upon just that thing.

He says (*pages* 4 *and* 5): "The employment of electrical variations or electrical undulations similar in form to the sound waves to which those variations were due originated with Mr. Bell, was first directed by him, enabled him for the first time to transmit speech, and *is precisely that which is claimed as novel in the 5th claim.* The Dolbear apparatus transmits speech by employing them, and causes them by the action of the voice on the transmitter."

The position, which in the Spencer case was declined as *dangerous in law*, is now taken by the complainant; hence *it is the only position from which Dolbear can be attacked as an infringer.*

In the Spencer case it was said that Bell "claims that method of employing electricity which consists in causing a special character of current variations by means of the sound waves themselves. If this claim practically monopolizes the electric transmission of speech, it is *not because his claim covers other methods*, but because no one has discovered any other."

It is now avowed that *there is no other possible.*

We think that the plaintiff's case requires the Court to advance to a position of law not, to say the least, heretofore judicially announced, and one which ought not to be taken without great consideration. We therefore invite their attention to a careful review of the law in regard to the limit of patentability.

We submit that the cases will be found to give no countenance to the idea that there may be a valid patent for the scientific law which necessarily underlies and is involved in the use of electricity for transmitting speech any more than there can be a valid patent for (in terms) the use of electricity for transmitting speech; that the spirit of the cases and the manifest reason of the thing are to the contrary.

The question of "patenting a principle" was first discussed by the Supreme Court in the *Lead Pipe case*, *Leroy* q. *Tatham*, 14 *How.* The Hansons were the first and original *discoverers of the fact* "*that lead, when recently become set, and while under heat and extreme pressure in a close vessel, would unite perfectly after a separation of its parts.*" Their patent described the process of making lead pipe by such separating and reuniting of the lead, and described certain machinery for the purpose, and the claim was as follows: "We do not claim as our invention and improvement any of the parts of the above-described machinery, independently of its arrangement and combination above set forth; what we do claim . . . is the combination of the following parts above described, to wit: the core and bridge or guide piece, with the cylinder, the piston, the chamber and the die, *when used to form pipes of metal, under heat and pressure, in the manner set forth, or in any other manner substantially the same.*" At the trial, Judge Nelson instructed the jury that it was not material whether or not the machinery was *new* or was *infringed* by the defendant, because *the invention consisted in bringing a newly discovered principle* (i. e. the reuniting under pressure of semi-solid lead after separation) *into practical application.*

The view of the law on which he proceeded is frankly and clearly stated by him in his dissenting opinion, where he says, "The settled doctrine to be deduced from them [the English cases] I think is that a person, having discovered the application for the first time of a well-known law of nature, or well-known property of matter, by means of which a new result in the arts or in manufactures is produced, and has pointed out a mode by which it is produced, is entitled to a patent and . . . to be protected against *all modes by which the same result is produced by an application of the same law of nature or property of matter;* and *a fortiori* if *he has discovered* the law of nature or property of matter, and applied it, he is entitled to the patent and aforesaid protection."

He also says, "*If I rightly comprehend* the ground upon which a majority of my brethren have placed the decision, they do not intend to controvert *so much* the doctrine which I have endeavored to maintain . . . as the application of it to the particular case."

The majority opinion does indeed say, "The question whether the newly developed property of lead used in the formation of pipes might have been patented, if claimed as developed, without the invention of machinery, was not in the case, because the machinery was made an element of the claim."

They express themselves, however, more or less clearly as to the broader question. They say that a principle cannot be patented; nor the exclusive right to the use of a new power, as steam or electricity, "or of any other power in nature, which is alike open to all, and may be applied to useful purposes by the use of machinery. In all such cases *the processes used to extract, modify and concentrate natural agencies, constitute the invention. . . . A patent is not good for an effect or the result of a certain process, as that would prohibit all other persons from making the same thing by any means whatever*, or producing the same result by any process whatever."

In *O'Reilly* v. *Morse*, 15 *Howard*, decided at the following term, the court refer to *Leroy* v. *Tatham* and state its understanding of that decision. They say: —

" It appeared that in that case *the patentee had discovered* that lead recently set would, under heat and pressure in a close vessel, reunite perfectly, after a separation of its parts, so as to make wrought instead of cast pipe. And the court held that he was not entitled to a patent for this newly discovered principle or quality in lead, and that such a discovery was not patentable, *but that he was entitled to a patent for the new process or method in the art of making lead pipe, which this discovery enabled him to invent and employ.*"

The court manifestly mean that, although the patentee had discovered that lead, when recently set, would, under heat and pressure in a close vessel, reunite perfectly, after a separation of its parts, so as to make wrought, instead of cast pipe, he was not entitled to a patent for *any and all modes* of causing lead, when recently set, to reunite under heat and pressure, after a separation of its parts, and so to make wrought instead of cast pipe, but only to *his* mode of doing it. For that mode his patent would be valid if it were clearly described.

So here: grant that Bell had *discovered* that if he could produce, by the action of the human voice, electrical variations of a certain kind on a line wire, and convert such variations into air vibrations again, the result would be the transmission of speech; this is only the scientific discovery which *underlies* his method, and which enabled him to practise his method.

The lead-pipe patent came again before the Supreme Court in 1859, this time *in equity*. (*Leroy* v. *Tatham*, 22 *Howard*.)

The opinion is extremely obscure. It refers to *Neilson* v. *Harford*, thus: "As no specification was claimed in regard to the machinery, it is not perceived how the patent could be infringed, unless upon the principle that, having claimed no specific mode of applying the heat, he could use any mode he might prefer, in defiance of the rights of other patentees. *Now this cannot be law. Certainly it is not law under the patent act of this country.*"

And then they quote Baron Alderson: "You must have an embodiment of the principle in *some practical mode described in the specification of carrying it into actual effect*, and then you take out your patent, not for the principle, but for *the mode* of carrying the principle into effect."

They proceed, — "The newly discovered property in the metal, and *the practical adaptation of it by these means* to the production of a new result, namely, the manufacture of wrought pipe out of solid lead, was the discovery."

The opinion closes with a *résumé* of *the functions* of the described machinery *as constituting the patentee's method.*

A decree was made sustaining the patent.

The second lead-pipe case is explained by Judge Blatchford in 9 *Blatch*. 304. He regards it as sustaining the patent for "the method of causing lead to separate and reunite at a welding heat under pressure in a close vessel *by the use of the machinery described to form lead pipe in the manner set forth*"; the machinery, being old, but its *functions* being patentable as constituting the *method* by which the capacity of the separate parts of the lead to reunite at a welding heat under pressure, is made available.

The opinion by Judge Blatchford in 6 *Blatch.* (*Poillon* v. *Schmidt*) itself furnishes a clear exposition and application of the law.

The inventor claimed to have discovered the fact that steam might be made self-packing by virtue of the construction of the surfaces to be packed. He made small grooves in the surfaces to be packed, and the steam introduced into these grooves itself formed a packing without the surfaces being in actual contact.

One Cavé had long before used exactly the same construction of grooved surfaces in *blowing cylinders* for the purpose of making *the air* pack itself.

The patentee's claim was " the method herein described, of causing steam to become a packing to itself in steam cylinders, or other parts of steam machinery, *by allowing the steam to act in one or more grooves*, substantially as specified."

The opinion says, " It is a claim to an art or process. It is not a claim to the grooved surfaces, but it is a claim to the process of the self-packing of steam, and in steam machinery *when* effected by allowing the steam to act in one or more grooves, as described in the specification. Gale undoubtedly was *the first to discover that steam could be made to pack itself*, and that it could be made to do so by causing it to act in the way described, in one or more grooves. . . . *The claim is not to all methods* of causing steam to become a packing to itself, in steam machinery, but to *the method described in the specification*, whereby the property of steam discovered by Gale is made to subserve a useful purpose by being carried into effect in a practical mode. The newly discovered property of steam, and the practical adaptation of it to a useful end, *by the means described*, is the invention made and claimed."

The case of *Tilghman* v. *Proctor*, 102 *U. S.*, 707, carefully reviewed the law as laid down in *O'Reilly* v. *Morse*, and affirmed and applied it. It also showed that the leading English case of *Neilson* v. *Harford* was in harmony with the decisions of our Supreme Court.

The claim in *Tilghman* v. *Proctor* was "the manufacturing of fat acids and glycerine from fatty bodies by the action of water at a high temperature and pressure." In other words, the separation of fatty bodies into their components, acid and glycerine, by the action, etc.

In an earlier case it had been decided by the Supreme Court that, as the method described in the patent effected the separation in a few minutes by subjecting the fat to a heat of 612° Fah., the defendant's method, which subjected it to only 400° Fah., and took several hours, was not an infringement, "although the process by which the effect was produced, namely, *the action of water in intimate mixture with the fat at a high temperature and under a sufficient pressure to prevent the formation of steam, was undoubtedly the same.*"

The Court was now "of opinion that in the case referred to sufficient consideration was not given to the fact that the patent is *for a process*, and not for any specific mechanism for carrying such process into effect."

It appeared that before the plaintiff's invention "two different processes for effecting a decomposition of fats into their component elements had been in practical operation . . . called respectively the alkaline — saponification process and the sulphuric — acid distillation process."

Tilghman's discovery, the Court say, was "that the fat acids can be separated from glycerine, without injury to the latter, by the single and simple process of subjecting the neutral fat, while in intimate mixture with water, to a high degree of heat, under sufficient pressure to prevent the water from being converted into steam."

The Court then reviews *O'Reilly* v. *Morse* and *Neilson* v. *Harford*, shows them to be in perfect accord, and proceeds to apply the law of those cases to the case before them. They say, —

"In the first place the claim of the patent is not for a mere principle.

" *The chemical principle or scientific fact* upon which it is founded is *that the elements of neutral fat require to be severally united with an atomic equivalent of water, in order to separate from each other and* *become free.* This chemical fact was not discovered by Tilghman. He only claims to have invented *a particular mode of bringing about the desired chemical union* between the fatty elements and water."

There is certainly nothing in the opinion to indicate that, if Tilghman *had* been the discoverer of "the chemical principle or scientific fact" that the elements of neutral fat require to be severally united with an atomic equivalent of water, in order to separate from each other and become free, he would have been entitled to patent all ways of effecting that union. It would have been like "the principle or scientific fact discovered by Neilson," as the same opinion puts it. Manifestly the Court would have disallowed a claim to the method of obtaining free fat acids *consisting* in causing the elements of the neutral fat to be severally united with an atomic equivalent of water.'

The case of *Neilson* v. *Harford* was rightly decided, because the patent was limited to *the patentee's method* of applying the discovery that hot air would promote the ignition of fuel better than cold, and that it could not validly have been for the use of that discovery for that purpose.

Now, if the patentee had stated what happened and must necessarily happen when hot air is used to promote the ignition of fuel, and had claimed broadly as *his* method *the production of those conditions,* the patent would have been manifestly void, as before, and for the same reasons: he would have been patenting the statement of the problem to be solved; but in fact he limited himself to his mode of solving that problem, viz., by interposing between the means of blowing the air and the means of burning the coal a means of heating the air on its passage from the former to the latter.

In the cases of *Leroy* v. *Tatham* and *Neilson* v. *Harford* and *Tilghman* v. *Proctor* (where the patent was sustained) it is manifest that the method employed by the plaintiff was not *the only one pos-*

sible for availing of the scientific fact. The objection we now make, viz., that the claim of *the method* was necessarily in substance a claim of the principle or scientific fact underlying *all* methods for that purpose, could not be made; and there is certainly nothing in those cases tending to support *such* a patent, but a clear indication that it would not be supported.

The case of *Morton* v. *The New York Eye Infirmary*, 5 *Blatch.* 116, was alleged infringement of the patent for the use of sulphuric ether in surgical operations. The decision was by Nelson and Shipman, JJ., the latter delivering the opinion. They first announce the general rule of law thus: —

"In its naked, ordinary sense, a *discovery* is not patentable. A discovery of a new principle, force *or law*, operating, or which can be made to operate, on matter will not entitle the discoverer to a patent. It is only when the explorer has gone beyond the mere domain of discovery and has laid hold of the new principle, force *or law*, and connected it with *some particular medium* or mechanical contrivance, by which or through which it acts on the material world, that he can secure the exclusive control of it under the patent act. He then controls his discovery *through the means by which he has brought it into practical action, or their equivalent, and only through them.* It is *then an invention*, although it embraces a discovery. Sever the force or principle discovered from the means or mechanism *through which he has brought it into the domain of invention*, and it immediately falls out of that domain, and eludes his grasp. It is then a naked discovery, and not an invention. . . . Every invention may, in a certain sense, embrace more or less of discovery, for it must always include something that is new; but it by no means follows that every discovery is an invention. It may be the *soul* of an invention, but it cannot be the subject of the exclusive control of the patentee, or of the patent law, until it inhabits a *body*, any more than a disembodied spirit can be subjected to the control of human laws."

Coming to the Morton-Jackson patent, which was before the court, they point out that *the discovery* was that the inhalation of the vapor of sulphuric ether, which had been already known to produce effects analogous to intoxication when practised in a certain degree, would, if carried further, produce a state analogous to complete intoxication, *accompanied by total insensibility to pain.* And they say,—

"That this mere discovery, however novel and important, is not patentable, needs neither argument nor authority to prove."

The opinion then goes on to discuss the several ways in which the complainants sought to evade the operation of the law: first, they contended that the invention was of *an improvement in the art of surgery*, consisting in facilitating surgical operations by etherizing the patient; and this the court regarded as merely claiming the advantages of the discovery.

Secondly, they contended that the invention was "an application of the discovery to surgical operations *by the means described*," and that by "the means described" was meant "the process of rendering the system insensible to pain by the inhalation of ether," to which the Court said, "What is the process which is here set forth? The process of inhalation of the vapors, and nothing else. To couple it with the effect produced, by calling it a process of rendering the system insensible to pain, is merely to connect the result with the means." In other words, it was an attempt to characterize a process for producing a certain result by saying that it *did* produce that result.

The patent was held void, and judgment followed for the defendant upon a verdict which had been rendered by direction of the court.

The case went no farther. The counsel for plaintiff was one of the ablest patent lawyers that ever lived in this country.

The parallel between that case and the case at bar is very striking.

There the discovery was that inhalation of sulphuric ether could be made to bring about an animal condition which had never before been brought about by any such means.

Here the discovery was that the utterance of speech could be made to bring about certain electrical conditions upon the line wire which had never been brought about before by any such means, which electrical conditions could be converted into speech again.

There, as here, the plaintiff's effort was to monopolize this abstract result by defining his method as *consisting in producing that result.*

There the patent was held void because, there being no novelty in the method by which the result was proved, there was nothing for the patent to stand upon.

Here, however, the patent is good for what Bell invented, viz., the *described method* of converting speech vibrations into electrical variations of similar form and converting them into speech vibrations again, — and any method substantially the same.

The opinion of the Court in the ether case closes with these remarks, very pertinent to the case at bar: —

"The beneficent and imposing character of the discovery cannot change the legal principles upon which the law of patents is founded, nor abrogate the rules by which judicial construction must be governed. These principles and rules are fixed, and uninfluenced by shades and degrees of comparative merit. They secure to the inventor a monopoly in the manufacture, use and sale of very humble contrivances of limited usefulness, the fruits of indifferent skill and trifling ingenuity, as well as those grander products of his genius which confer renown on himself and extensive and lasting benefits on society; but they are inadequate to the production of *every discovery*, by securing its exclusive control to the explorer to whose eye it may be first disclosed. A discovery may be brilliant and useful, and not patentable. No matter through what long, solitary vigils, or by what importunate efforts the secret may have been wrung from the bosom of nature, or to what useful purposes it may be applied, something more is necessary. The new force or principle brought to light must be embodied and set to work, and *can be patented only in connection or combination with the means by which, or the medium through which, it operates.*"

We suppose the present case to be exactly within the law as defined in the foregoing cases, and especially the latest one, *Tilghman* v. *Proctor*.

The scientific fact is that if speech is to be telegraphically transmitted the speech vibrations must themselves, by *some* means, produce undulations in an electric current corresponding in form with the speech waves; and these electrical undulations must by *some* means be converted into speech waves again.

Doing this, no matter how, cannot be patented under our law.

Only some one method of doing it can be patented.

And the great question of the case is, can the Bell method be so limited as to be a patentable subject, and at the same time embrace Dolbear's as an equivalent?

We accept as correct the statement in Judge Lowell's opinion in the Spencer case: "The *invention* is nothing less than the transfer to a wire of electrical vibrations like those which a sound has produced in the air. *The claim is not so broad as the invention.* It was undoubtedly drawn somewhat carefully in view of the decision in *O'Reilly* v. *Morse*, and covers *the* method and apparatus, that is, *any process* and any apparatus *of substantially similar character to those described.*"

Prof. Cross, in his affidavit (*page* 12) says: "*Mr. Bell's method* is defined in the fifth claim of his patent. . . . In this claim Mr. Bell pointed out *as the distinctive feature of his method that the electrical variations, in their successive changes, should conform to the law which expresses the vibrations of a particle of air engaged in producing the sound to be transmitted;* the apparatus was to be one in which the action of the voice should produce this special type of electrical undulations. He was the first who had pointed out this method (or any method) competent to transmit speech by electricity. His novelty of result was due to this novelty of method. Mr. Dolbear's apparatus accomplishes this same result *because in action it conforms to and employs this novel method.*"

But it is *not* what our law regards as "a method" of using electricity to transmit speech. It is the scientific fact which it involves necessarily in *any* method of transmitting speech by electricity. Of course it is embodied in Dolbear's method, because his *is* a method of transmitting speech by electricity. But that is not enough. It must appear that *his* method of transmitting speech *by* causing electrical undulations similar in form to the vibrations of the air accompanying speech, and reconverting such undulations into speech vibrations again, is substantially like Bell's.

What then is *Bell's* method?

In the first place it is a method of *transmitting speech*, not of *transmitting electrical variations*.

It is not complete until the speech uttered at the transmitting station becomes again speech audible at the receiving station.

This plain distinction makes it immaterial whether or not Dolbear practises Bell's described methed of producing electrical undulations upon the wire and transmitting them *to the other end of that wire*. If then they "die and make no sign," that is not a method of transmitting *speech* at all.

The question is of Bell's method of transmitting *speech*.

Let us assume, for the purposes of this argument, that Bell's method of *producing* the necessary undulations in the line wire includes *broadly* causing the speech vibrations of the air to act upon any instrument exposed thereto as to produce variations of current corresponding with such speech vibrations of the air.

What *is* the current which he varies, and *how* does such variation of it bring about the result of the transmission of speech?

Look first at Bell's statement in his affidavit (*page* 19).

He there refers to *Reis* in contrast with himself, and we must understand *Reis* in order to understand Bell.

We have no idea of putting Bell in the light of a mere improver upon Reis. We are not now referring to the Reis instrument as having been either in kind or in degree a speaking telephone at all. But we must take the state of the art of telegraphic transmission of *sound* as Bell found it, in order to form an intelligent judgment as to his invention, — *what mode of using electricity for the transmission of speech* he invented.

Reis transmitted *sounds* over a telegraphic circuit by causing the air vibrations to make and break that circuit at varying rates per second, so producing charges and discharges of the electro-magnet at the receiving station, and corresponding musical vibration of a plate set up in the magnetic field.

He did not (this Court has decided) know or teach how to transmit articulate speech, and this for want of two things: first, a way of converting speech vibration with electrical variations, and, secondly, a way of reconverting electrical variations into speech vibrations.

What did Bell do? He tells us in his affidavit,

" Before this time [May, 1875] I had perfectly satisfied myself that . . . the electrical transmission of speech *depended* upon producing upon the line wire electrical undulations or variations which should correspond in form to the aerial vibrations which constituted the sound to be transmitted, and I perceived that a *circuit-breaking* apparatus (such, for example, as the Reis transmitter) was totally inadequate to do this, because it merely tended to intermit *the current*, and not to control it, — to govern its changes as to frequency, but not as to intensity or form or character. I was aiming to perfect an apparatus which should carry out my method in two ways: one by varying the electro-motive force in a circuit of constant resistance, and the other by varying the resistance in a circuit supplied with a constant electro-motive force. I intended to do both of these by means of the vibrational movement taken up by stretched membranes or elastic metals when spoken to."

But merely *producing* the necessary undulations upon the line wire by the vibrational movement of membranes or plates, causing variations of resistance or of electro-motive force in a circuit, would not give him *audible speech*.

We must now see what *circuit* he had in mind, what it contained, and what were its functions in the proposed method.

There was at the time of Bell's invention nothing known as *a tele-*

graphic circuit, except such as is referred to in the following testimony of Professor Cross, speaking of the essentials of the Bell method: "The electrical circuit of the instrument must always present an uninterrupted path by which the continually varying current may travel from the transmitter to the receiver; that is, the circuit containing the battery or other source of electrical power, the transmitter, line wire, receiver *and earth or return wire*, must always be closed."

The current travels continually, though with undulations, from the transmitter to the receiver, and thence to earth or return wire, and so home, in a constantly closed circuit.

This was the known telegraphic circuit used by Reis, except that *he* did not keep it constantly closed. *This telegraphic circuit necessarily included a core*, around which the line wire was coiled at the receiving station, and which was *made magnetic by the passage of the current around it* as it traversed the circuit, and whose magnetic condition was made by Bell to vary in exact conformity with the electrical variations on the line wire, which again were in exact accordance with the variations of the speech waves.

Bell, then, was dealing with the known telegraphic circuit *with its electro-magnet at the receiving station*, energized by the current flowing past it through its coils. Over this current Reis had transmitted musical tones. Bell proposed to transmit articulate speech over it.

And the method which he invented for this purpose (I read from the affidavit of Mr. Pope, one of the defendant's witnesses), comprised the following series of successive steps or operations, viz.:

"1. The communication of physical motion from the air [by the act of speech] to the transmitting diaphragm. 2. The production of electrical undulations in the conducting circuit by the motion of the diaphragm. 3. The production of varying degrees of magnetic intensity in the core of an electric magnet, by the action of an undulatory electric current traversing its enveloping coil. 4. The production of physical vibrations in a resonant plate by the varying magnetic attraction to which it is subjected by the said electro-magnet. 5. The production of sonorous [speech] vibrations in the atmosphere by the physical vibrations of the resonant plate."

We will come, later on, to the fact that, at that time, there was no known way of utilizing electrical variations for the purpose of producing sonorous vibrations of anything, except by varying an electrical current passing around a magnetic core, and so producing magnetic variations.

We wish now to show:

1. That Bell's specification is in full accordance with the above definition of his method; and
2. That no other definition was involved in the Spencer case.

As to Bell's specification:

There is certainly not a word in it expressing or implying that he intended to use, or supposed it possible to use, any electrical circuit except the well-known one with its receiving electro-magnet. In the only places in which he does describe what is at the receiving station, he describes an electro-magnet with its armature vibrating in correspondence with the sounds transmitted.

2. *As to the Spencer case:*

The decision in that case is the chief equity in support of the present motion for interlocutory injunction.

It is the only decision which has been made on *the merits* of the Bell patent.

The *Eaton* telephone (held infringement in the Spencer case) *transformed sound vibrations into electrical undulations on the line* by variations of pressure between two electrodes in contact with each other, such variations of pressure being communicated through a vibrating diaphragm.

These electrical undulations on the line were *utilized,* i. e. translated into sound variations again at the receiving station, *by causing the undulating current to traverse the coils of an electro-magnet* at the receiving station, thus producing *magnetic variations* corresponding in form to the electrical undulations on the line wire, which magnetic variations caused and permitted corresponding vibrations of a diaphragm set up in the magnetic fluid, which vibrations of the diaphragm produced audible sounds like those uttered at the transmitting station.

Thus Spencer converted speech waves into electrical undulations *in one of the ways suggested in Bell's patent*, viz., by interposing a variable resistance in the circuit, and he re-converted his electrical undulations into speech waves in the *only* way suggested in Bell's patent.

The contention of the case was confined to that part of Bell's invention which related to *the conversion of speech waves into electrical undulations*.

The plaintiff contended that Bell's method, in this respect, was (broadly) *controlling the electric current continually* by an instrument vibrating under the action of the speech waves, so that *every motion* of that instrument, during *every part* of its path, should continually control the current and compel it to vary in accordance with all variations of character in the sound waves.

This was regarded as a new method of employing electricity for the purpose of producing variations in an electric current, *and consequent variations in a magnet around which that current passed.*

The counsel for Spencer endeavored to show that this broad method of converting speech waves into electrical undulations, and these again into magnetic variations, was not new with Bell.

He was unsuccessful. And for the purposes of the present motion, we cannot and do not seek to impeach the judgment of the Court on that point.

That nothing was contended for by the plaintiff in the Spencer case beyond the broad novelty in the method of converting speech waves into undulations of *the current flowing through a telegraphic circuit, including an electro-magnet at the receiving station*, further appears from the following passage on page 14 of the complainant's brief used in that case:

"His [Bell's] invention set forth in the claim 5 may be described as follows: 'Provide at the transmitting station a diaphragm or plate so sensitive that when spoken to, it will take up from the air all the *character* of the air vibrations with fidelity. Provide at the receiving end *an electro-magnet and an armature* which is capable of the same motion as that taken up from the air by the transmitter, and which has surface enough to impart those motions to the air. Obviously if *this diaphragm* [the armature of the electro-magnet] can be compelled to copy the motions of the diaphragm of the transmitter in all its characteristics, then the same sound which is uttered against one and actuates it will be heard to proceed from the other.'

"Could a method of employing electricity be discovered which would accomplish *this result!*"

Plainly the Bell method *then* was a method of producing *magnetic* variations (and consequent speech vibrations) at the receiving end, similar to the speech vibrations at the transmitting end, by means of electrical undulations produced on the line by the action of the speech waves.

Nowhere in the testimony then relied upon by the plaintiffs, or the arguments made in his behalf, do we find any intimation that the Bell method involves or includes any other mode of *re-converting the electrical undulations into speech waves* than by the use of *magnetic variations induced by the passage of the undulatory currents around and past a magnetic core placed in the circuit at the receiving station.*

We maintain here that no other mode of doing so was known or believed to exist at the date of Bell's patent.

We will now proceed to show that nothing more than or different from that was accorded to Bell as his method, by the opinion of Mr. Justice Lowell.

He says:

"The *invention* is nothing less than *the transfer* to a wire of electrical vibrations like those which a sound has produced in the air."

(That is to say, Bell was in fact the first who transferred to a wire — meaning of course the wire of a telegraphic circuit — electrical vibrations corresponding in *all* respects with those which *any* sound — speech included — has produced in the air.)

"*The claim is not so broad as the invention. It was undoubtedly drawn somewhat carefully in view of the decision in O'Reilly* v.

Morse, 15 *How*. 62, and covers *the* method and apparatus, that is *any method* and any apparatus *of substantially similar character to those described.* The patent points out distinctly that *the undulations may be produced* in other modes besides the vibration of an armature in front of a magnet; and the defendants make use of a mode not wholly unknown at that time, though much improved, *in creating their undulations.*

"It seems to me that the defendants use both the method and the apparatus of Bell. The essential elements of the method are *the production of* what the patent calls undulatory vibrations of electricity to correspond with those of the air, *and transmitting them to a receiving instrument capable of echoing them.* Granting that the defendants' instrument *for converting the vibrations of the diaphragm into vibrations of electricity* is an improvement upon that of the plaintiffs, still *it does the same sort of work,* and does it in a mode not wholly unknown at the date of the patent, though I do not consider that material."

1st. As to *the production* of the undulations, or the mode of converting speech waves into electrical undulations.

When the Court compares the defendant's "instrument" for this purpose with the plaintiff's, it evidently means by the plaintiff's *an armature vibrating in front of a magnet. This* and the variable resistance device of Spencer, the Court says, *do the same sort of work;* and it adds that it is not material whether or not the defendant's mode of doing it was known at the date of Bell's patent.

By "the same sort of work" we must not understand that both "transfer to a wire electrical vibrations like those which a sound has produced in the air." For *this* construction had been already adverted to in the opinion as dangerous in view of *O'Reilly* v. *Morse.*

We must understand the Court as saying that to cause undulations in the current by varying the resistance in the circuit through which the current flowed, and to cause such undulations by varying the electro-motive force of the current itself, were doing substantially the same thing for the purposes of Bell's invention. Such was the argument for the plaintiff (*see page* 15 *of their brief in the Spencer case*).

But note in each case the ultimate work done was to produce desired variations in a current flowing through an electrical circuit, which variations of current induced corresponding variations in a magnetic core included in that circuit.

2. Bearing in mind that when speaking of the means of converting speech vibrations into electrical undulations, the Court expressly says that Bell could not (under *O'Reilly* v. *Morse*) cover *all* modes of doing that, but only his described mode and such as were substantially the same, we have now to apply the same rule to the means of coverting the electrical undulations into speech vibrations again; for until this is done, *no transmission of speech is accomplished.*

Bell cannot, according to Judge Lowell's decision, cover all modes of doing this, but only his described mode or such others as are substantially the same.

We have seen that *the only described mode* was by causing the current which traversed the telegraphic circuit to produce in an electro-magnet, by passing through the coils surrounding it, *magnetic variations* corresponding with the electrical undulations in the line wire.

The question now is whether Dolbear's method of converting electrical undulations in the line wire into speech vibrations is substantially the same.

In Bell the *electrical* undulations are converted into *magnetic* variations.

In Dolbear this is *not done at all.*

This is an undeniable and weighty fact.

Again. The electrical undulations utilized in Bell are radically and essentially different from those utilized by Dolbear — this will be made plain hereafter.

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A COMPARISON IN DETAIL BETWEEN THE TWO METHODS AND THE TWO APPARATUSES.

Inasmuch as speech consists in peculiar motions of the air, which motions may be called speech waves, the first step must be to cause these speech waves to act *in some way*, so that other waves substantially like them may be produced at the desired place, the production of this second set of speech waves being the last step.

In a speaking tube the speech waves are produced by the voice at one end of a long column of air, separated from the surrounding atmosphere, and propagated through that long column of air, the mouth of the speaker being at one end of the column, and the ear of the hearer at the other end.

In the mechanical telephone, the energy of the speech waves is caused to give motion to a plate, and that plate is mechanically connected to the plate which produces the second set of speech waves.

In the transmission of speech by electricity, the energy of the speech waves produced by the speaker is utilized to give motions to a plate near the mouth of the speaker, and these motions of the sending plate must generate or control electricity, which in turn, must cause the receiving plate near the ear of the hearer to copy the motions of the sending plate.

The principal method described in Bell's patent consists in the following steps or sub-methods: first, the energy of the speech waves is utilized by setting in motion a plate capable of inductive action; and as this plate is near the pole of an electro-magnet, through the coils of which a constant battery current is passing, the electromotive force of that current is increased whenever the plate moves **towards the magnet**, and decreased whenever the plate moves away from the magnet; and as the resistance of the circuit is always the same, the strength of the current through the circuit is increased by increasing the electro-motive force, and decreased by decreasing the electro-motive force.

These terms, *electro-motive force*, and *resistance*, are fully explained in the affidavits, — the first meaning, in substance, the electric pressure, tension or head, or that which tends to cause electricity to flow; and the second being friction, or obstruction, or that which tends to prevent electricity from flowing. The nearest analogy is the head of water, and the friction of water in its channel; the higher the head, the greater the current through a given channel; the less the friction in the channel, the greater the current through that channel from a given head.

To return to Bell's principal method: The first step, as has been said, is to utilize the energy of the speech waves to vary electro-motive force; and the apparatus employed for practising this sub-method, is an inductive plate and an electro-magnet and its coil, with a constant battery current passing through the coil. The second step, or second sub-method of this principal method of Bell, consists in utilizing the varying current thus produced in the circuit, by converting the dynamic energy of this varying current into magnetism, the magnetic energy varying, of course, in accordance with the variations of current producing it. The third step, or third sub-method of Bell's principal method, consists in utilizing the energy of these magnetic variations, to give motion to a second plate, which motion sets up vibrations in the air. The apparatus employed in carrying out these two steps, is a conductor circuit, where resistance is constant and as little as possible, a second coil or helix forming a part of this conductor circuit, a magnet in this second coil or helix and its armature, adapted to act as the receiving plate.

This is the principal method and apparatus described in Bell's patent; and, so far as now known, Bell is the first who ever attempted to transmit speech by this method, namely, causing the energy of the speech waves to vary a current by varying its electro motive force, transmuting the varying dynamic energy of that current into variations of magnetic energy, and these into motions of the receiving plate. But this method is of limited practical use, for the reason that the maximum variation of electro-motive force is necessarily small (depending upon the energy of the speech waves), so small in fact that it is practically neutralized by the resistance necessarily incident to the average line; consequently this specific method is not in practical use.

But it was well known, before the date of Bell's invention, that there were two ways of varying the strength of a current of electricity, namely: by varying the electro-motive force, leaving the resistance constant, and by varying the resistance, leaving the electro-motive force constant. This is clearly pointed out in Bell's specification; consequently, that method of transmitting speech electrically which consists in utilizing the energy of the speech waves to vary the resistance in a circuit, thereby varying the dynamic energy of the current traversing that circuit, and utilizing this varying dynamic energy as before, must fairly be regarded as substantially the same as the specific method principally described in the Bell patent, both being fairly described in that patent, and one differing from the other in nothing, except as to the specific method of, and apparatus for, utilizing the energy of the speech waves to vary the dynamic energy of the current. Neither of these specific methods is in practical use, because in both the resistance in practical lines is very large in comparison with the maximum variation of electro-motive force or resistance which can be got by the direct use of the energy of the speech waves.

For these reasons, an improved form of the Bell method and apparatus is in common use, in which the energy of the speech waves is utilized to vary the resistance in a very short circuit, so that the range of variation is large in comparison with the total resistance of the circuit. The variations of current in this short circuit are utilized by being converted into variations of magnetic energy at the sending station, and these variations of magnetic energy at the sending station are converted, in a manner well known before Bell's invention, into currents on the line circuit which are adapted to do their work, in spite of the resistance of the average line. This specific method and apparatus was held in the Spencer case to be substantially the same as Bell's method and apparatus; and that conclusion seems unavoidable, even were Bell's patent limited to the principal method described in it; for, in the method in ordinary use, shown in figure I of the affidavits, the energy of the speech waves is first converted into motion of the plate, at the sending station, and this motion into magnetic variations, these into variations of current,

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and these again into magnetic variations and motion of the receiving plate; being precisely the principal method described in the Bell patent, except in one particular, namely, that the motion of the sending plate caused by the speech waves is not converted *directly* into magnetic variations, as in Bell's principal method; but indirectly, by first varying the resistance in a short circuit, thereby varying the current in that short circuit, the dynamic energy of which current is then converted into magnetic variations at the sending station.

Whichever of these specific methods be used, the practical efficiency depends wholly upon the range of variation in the dynamic strength of the current traversing the line. This current strength depends wholly upon the electro-motive force of the electricity and the total resistance, both internal and external, and is greatest in that specific method illustrated in figure I of the affidavits, where the internal resistance — that of the secondary coil — is equal to the resistance of the line, or that part of the line conductor which extends from the ends of the secondary coil. Moreover, the greatest efficient dynamic strength which can be attained by the best form of the Bell apparatus, as shown in figure I of the affidavits, is many times less than is desirable for practical use, and improvement of the Bell method must result from increasing the dynamic strength of the currents traversing the line.

By "dynamic strength" is meant that sort of current strength best adapted to produce dynamic or kinetic effects.

In the defendant's method, the energy of the speech waves is converted into motion of the sending plate, and this motion into magnetic variations at the sending station, these steps being the same as the corresponding steps in the Bell method. But the energy of the magnetic variations produced at the sending station is *not converted into substantially the same electric variations as those utilized in the Bell method.* It is true that in both methods the energy of magnetic variations due to the motion of the sending plate is converted into electric variations at the sending station. But in the Bell method, the aim is to convert this magnetic energy into currents having the greatest possible dynamic strength, and into that sort of currents, (viz., flowing from ground to ground, or over a ring circuit,) which were the only currents utilized before Dolbear's discovery, which must have a certain dynamic strength to give any effect whatever in the Bell method, and *whose operation in the Bell method is good or bad as their dynamic strength is large or small;* while in the Dolbear method, the energy of these magnetic variations is converted into electricity, *whose dynamic strength is absolutely immaterial,* and a mere incident, and very many times too small for practical use in the Bell method, while its electro-motive force, or tension, or pressure is vastly greater than any ever used or required in the Bell method.

It was known long before Bell's method that electricity had two properties, very much as water has two properties, namely: first, pressure or head, or that property which tends to make it flow, and which can exist by itself only in the case of an insulated and charged body, or a reservoir of water; and secondly, that dynamic property arising from its motion, and which never can exist by itself, but depends upon the quantity in motion and the rate of motion. This is not an absolutely exact way of expressing it, for the reason that electricity is not a fluid; but were it a fluid, the statement would be entirely exact. The point is, that every possible dynamic effect of electricity has a definite relation to the electro-motive force, pressure, or head, in view of the resistance, obstruction, or friction, precisely as the dynamic effects of water depend upon the motive force, pressure, or head, in view of the resistance, obstruction, or friction impeding its motion.

In the Bell method, the energy of the magnetic variations at the sending station must be converted into electricity of that electro-motive force which, in view of the resistance of the line, will give the maximum range of dynamic effect; and in accordance with laws perfectly familiar long before Bell's invention, the best possible secondary coil is that whose internal resistance equals the resistance of the rest of the line; and, in accordance with the same laws, the resistance of the line must be as little as possible, in order to obtain the best effect. In short, the electro-motive force, pressure, or head of the electricity into which the energy of the magnetic variations at the sending station is converted, in all Bell lines now in use or ever heard of before this controversy arose, was a mere incident, the dynamic effects being what were essential, and it being impossible to get the maximum dynamic effects with a line of a given resistance, unless the generator, which is the secondary coil in all practical Bell lines, had a certain internal resistance, and consequently, generated currents of a certain electro-motive force.

The energy of the magnetic variations at the sending station, in the Dolbear method, must be converted into electricity having a very great electro-motive force, pressure, or head, substantially without dynamic properties; that is to say, a given energy, no matter what, can be converted, at pleasure, into electricity of maximum dynamic property, or into electricity of maximum static property, but the sum of the two must always be the same, and one property can therefore be enhanced only at the expense of the other.

For example: it was at one time believed that there were two kinds of electricity, frictional and galvanic; but it has for many years been known that frictional electricity is electricity of very high electromotive force, and capable of producing only trifling dynamic effects; while galvanic electricity is of comparatively low electro-motive force, but capable of producing large and important dynamic effects. The one may be well likened to a thread of water thousands of feet high, exerting a pressure at its lower end of thousands of pounds to the square inch; the other to the water in a mill pond. There is but one fluid, but the properties of it are, nevertheless, radically different, — for difference in degree, carried beyond a certain point, is a radical difference.

In Bell's method, the electricity generated by the energy of the magnetic variations at the sending station does its work by flowing spirally and many times around a magnet, and does its work in accordance with laws well known and familiar long before Bell's invention. In Bell the potential is at the maximum at each end of the secondary coil, positive maximum at one end, and negative maximum at the other end, and diminishing to zero. In the Dolbear method the electricity charges the entire line, bringing all parts of the line connected with one end of the secondary coil to the same potential; that is to say, the potential in all parts of the line connected with one end of the secondary coil is the same as the potential at that end of the secondary coil, and there is no zero point in the line. The whole line is insulated, the whole line is charged, and *the only current is that necessary to bring all parts of the line to the same electric tension, pressure, or head.* There is nothing in any way resembling this in the Bell method. The electricity in the Dolbear method does not do its work by passing spirally many times around a magnet, nor in any way at all resembling that, nor in any way known before Dolbear's discovery. All work done by electricity before Dolbear's discovery, with a few trifling exceptions, spoken of below, depended wholly upon the dynamic property of electricity, — for instance, telegraphy, telephony, electric lighting, electro-plating, electricity as a motive power, electricity in its chemical action and heating action, and in fact all applications of it to any industrial or commercial purpose. Up to the present time Professor Trowbridge knows of only one practical application of its static property, except the Dolbear telephone, and that application is recently discovered.

There are no electric currents in the Dolbear method, exepting those incident to charging the line, called currents of charge. These currents are but a very small fraction of such as are now, and have always been, used in the Bell method, and *are of no practical utility in the Bell method.* (See affidavits for defendants in rebuttal.)

In the Bell method, the line used should be of the least resistance practically possible; that is, of the greatest area in cross-section. In the Dolbear method, it should be of the least possible area in cross-section, the resistance being always infinite. The reason of this is, in the Dolbear method, the surface of the line should be as little as possible; for the charge, or pressure, or tension, is alike on all parts of the surface; that is, the whole surface of the line must be charged, or brought to a given and high electric pressure, or tension, or head. There is nothing at all resembling this in the Bell method, for no part of the Bell line can be brought to any higher electric pressure, tension, or head, than that due to the resistance of the line, which must be as small as possible for the best results. In the Bell method, the work is done wholly by variations of the current flowing through the helix of the receiver into ground, or some other reservoir. There is nothing at all resembling this in the Dolbear method, where the work is done wholly by the presence of a certain electric tension, pressure, or head, at the plates of the receiver, and which is alike over all that part of the line between one of the plates and that end of the coil with which that plate is connected. In Bell's method, no practical work can be done unless both ends of the line be grounded, or a ring circuit be used. In Dolbear's method, if you complete the circuit by connecting the two plates by means of a wire, for instance, no work whatever can be done. A closed circuit is essential in one, and fatal in the other. The affidavits of defendants in reply attempt to show that a broken circuit can be used in the Bell method, but, taken in connection with affidavits for defendants in rebuttal, it is clear that they prove nothing more than what was before well known, and never was disputed, namely, that all charging currents will produce some trifling dynamic effects, and that the Bell receiver is, or may be made, so exceedingly sensitive that, under very favorable conditions, these exceedingly small currents will give speech audible under very favorable conditions; but nobody has testified that there ever was a practical Bell line without a closed circuit; and it is submitted that the affidavits in rebuttal demonstrate that there never will be one.

To sum up, both methods are the same, up to and including the magnetic variations at the sending station; but in Bell, the energy of these magnetic variations is converted into electricity of the lowest possible electro-motive force; the line has the lowest possible resistance, the dynamic property of the electricity alone is utilized, and utilized by conversion into magnetic variations at the receiving station. In order to be so converted, it must flow spirally and many times around a magnet, and into ground or some other reservoir. The potential is at the maximum at the ends of the coil, and can never be greater than that due to the resistance of the line, which must be as small as it can be practically made, to give the best effects.

In Dolbear, the energy of the magnetic variations must be converted into electricity of very high electro-motive force, enormous in comparison with anything ever found in any practical Bell line. The resistance of the line must be practically infinite. The dynamic property of the electricity is very trifling, and not utilized at all; there is no conversion of electricity into magnetic variations, nor any flowing of it in a spiral, or anything at all resembling this. Its static properties only are utilized, and it acts by its mere presence, under sufficient tension at the plates of the receiver. It is forced into these plates, but does not flow beyond them. There is nothing in Dolbear's at all resembling the ground or its equivalent, the ring circuit, essential to the proper operation of Bell, and the presence of any such thing in the Dolbear line would wholly prevent its operation. The potential at every point in the Dolbear line is the same as the potential at the end of the coil with which the line is connected, and the resistance must be enormous, and it is better to have it infinite.

The advantages of the Dolbear method and apparatus over the Bell are explained by Professor Dolbear on pages 13 and 14 of evidence for defendants, by Professor Trowbridge, bottom of page 26 and top of page 27, evidence for defendants, and by Mr. Buck, pages 30 and 35, evidence for defendants. They spring largely from the fact that current variations, which alone will work the Bell receiver, are impossible in the Dolbear line; but also from the fact that the helix of fine wire, which is an essential part of the Bell receiver, is not used in the Dolbear receiver. It will be observed that the complainants' affidavits in reply contain nothing in contradiction to the statements just above referred to.

The defendants also contend that the affidavits prove that Professor Dolbear is entitled to very high rank as a discoverer, and that not only was there nothing in the state of the art to lead any one skilled in the art to expect that variations of electric pressure or tension, or charge, could be used to transmit speech, but that all that was known as to the transmission of sound by such variations tended to show that they could not be used to transmit speech.

It was well known that an electrified body would attract an oppositely electrified body, or any other body except such as were electrified like the first; but no practical use whatever had ever been made of this law before Dolbear's discovery, and no use of any kind, except scientific measurements of the electric condition of charged bodies, unless it be in the experiments of Wright, Thomson and Varley, referred to in the affidavits, descriptions of which are printed on pages 44 to 47, defendants' affidavits in reply. Of these, Wright's instrument is, at first glance, much like the Dolbear apparatus; but it is clear, from the description of it, that it was a condenser, rapidly charged and discharged, each discharge being accompanied by a sound like a sharp tap of a small hammer. It was never thought capable of *reproducing* sound, but did simply what the Page magnet had done years before, namely, produce a sound not at all resembling that actuating the transmitter, except in rate per second or pitch.

Varley took up the Wright instrument, changing it somewhat in form, but used an ordinary circuit-breaker instead of the Reis transmitter used by Wright.

That form of the Wright condenser described on the bottom of page 46 was also operated by charge and discharge. The same thing is true of the experiments of Sir William Thomson.

In all these instances, it is clear that there was no sound given out by the condenser, except a series of sounds, *each like all the others*, but succeeding each other so rapidly as to produce pitch. Whether these charges were disruptive or not, is of no consequence. The material fact is, that the only sounds produced were each like all the others, and depended upon the number of makes and breaks in the primary circuit.

In brief, it was known before Dolbear's discovery that sudden charge and discharge of the opposed plates would give out a sound, and that repeating this frequently would give a series of sounds. But "The fact that a condenser will give out a sound when suddenly charged or discharged, has no relation to the fact that sound waves can be produced in air by *varying* the potential of the plate opposed to some other body. It is not possible, in the nature of things, to produce speech by charging and discharging a condenser, no matter how it is done; for the discharges are practically instantaneous, and the sound waves of speech require definite times." (*Page* 5, *evidence for defendants.*)

The use of the electric tension, pressure or charge, never absent, but varying, almost infinitely, within a certain range, with inconceivable rapidity, is obviously radically different from the rapid charging and discharging of a condenser, just as the use of a current varying widely, and from moment to moment, in strength, but never wholly interrupted, is obviously a different thing from the use of rapidly succeeding currents, each of a given strength, or from the use of a continuous current, at one moment of a certain strength, then for a brief period of a certain other strength, but always practically of a definite strength, and wholly lacking the wide range and endless variety of the current described in the Bell patent.

Moreover, the experiments of Wright and Thomson were widely known for many years before Professor Dolbear's discovery, and never led to that discovery. Professor Dolbear's discovery was made while experimenting with an electro-chemical telephone, as described by him at the bottom of page 4 and top of page 5, evidence for defendants.

Bell seems to have been the first to clearly apprehend the physical law which must be followed in the construction of a telephone to transmit speech by electricity, namely, that the energy of the speech waves should first be in some way converted into a continuous current of electricity of necessary strength to reproduce them, varying from moment to moment, just as a particle of air in the speech waves varied its motion from moment to moment; secondly, that this varying current must, in some way, be used to produce speech waves like the first. But this did not entitle him to a patent, under our laws. In order to entitle himself to a patent, he had to devise a method of, and apparatus for, converting the energy of the speech waves into this varying current, and a method of, and apparatus for, re-converting this varying current into speech waves like the first. Had he proceeded no further than the first step, namely, devising an apparatus for converting the energy of the speech waves into this varying current, it is submitted that he could not have had a valid patent, because he had accomplished nothing, up to that time, except of a purely scientific value. To test this, suppose he had obtained a patent, stating in substance that he had discovered the law under which all must work who desired to make an electric speaking telephone, then given a clear statement of that law, and then a clear explanation of his method and apparatus for converting the energy of the speech waves into electric undulations, like in form to the speech waves; and after that had stated that he had not, up to that time, been able to devise any means for utilizing these electric undulations, but was devoting himself to that end, and hoped to be able at some time to accomplish it, and thereupon claimed, first, all electric speaking telephones made in accordance with the law discovered by him, and, secondly, the method of, and apparatus for, converting the energy of the speech waves into electric undulations like in form to the speech waves, — it is submitted that the supposed first claim would be void, under well-settled rules of law, and that the supposed second claim would be void, because not a patentable subject. Certainly no patent has ever been granted for any method or apparatus whose sole function was to produce a peculiar electric current, which current could not be utilized by any means then known.

While admitting it to be true that the defendants' method and apparatus is an electric speaking telephone, and therefore that it is constructed under that physical law applying to electric speaking telephones, and also admitting that this law was first clearly perceived or discovered by Bell, and also admitting that in defendants' method and apparatus the energy of the speech waves is used to vary the resistance of the primary circuit, thereby causing electrical undulations in that circuit, similar in form to the vibrations of the air constituting the speech waves, —it is submitted confidently that the electrical undulation utilized in the defendants' method and apparatus are radically different from those utilized in the Bell method and apparatus, and do their work in a radically different manner; that the apparatus of defendant for producing and utilizing the electric undulations used by him, is radically different from the Bell apparatus for producing and utilizing the Bell electric undulations; lastly, that there is no hint or suggestion in the Bell patent of any method or apparatus at all resembling that part of defendants' method and apparatus which is concerned with the production and utilizing of the Dolbear electric undulations, and that these parts of the Dolbear method and apparatus were wholly unknown until discovered and invented by Dolbear.

CAUSTEN BROWNE,
J. E. MAYNADIER,
for Defendants.

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1628.

AMERICAN BELL TELEPHONE CO.
v.
AMOS E. DOLBEAR ET AL.

CLOSING ARGUMENT
OF
CAUSTEN BROWNE
for the Defendants.

ARGUMENT.

It seems to me, may it please the Court, that the great and controlling question in this case is the question of law, whether the ground of patentability upon which the plaintiffs put the case of infringement, and upon which, as we think, they must put it if they are to prevail, is a ground which the law of the land permits to be occupied exclusively by a patentee.

Before I begin to discuss the question, may I read the remarks which I find in a reported judicial opinion, expressing much more forcibly than I could do, what I wish to say in introducing that discussion?

The language I shall read is from the opinion given by the Court in case of *Morton* v. *The Eye Infirmary of New York*, 5 Blatch. 115, in which the Morton Jackson patent for the use of sulphuric ether in the art of surgery was held to be void. The opinion is drawn by the former Mr. Justice SHIPMAN, acknowledged on all hands to have been a very able judge in the patent law, possessing singular power of judicial statement. The opinion was concurred in by Mr. Justice Nelson, a fact worth noting, because, at one period of the history of this question, Mr. Justice Nelson dissented with so much force and earnestness from certain judgments of the Supreme Court. I may add, that upon the patent being held invalid, the plaintiffs, although represented by one of the best patent lawyers that ever lived in this country, Mr. Charles M. Keller, gave up the controversy and the case went no farther. Speaking of the invention of the plaintiffs in that case, the Court say, —

"Its discoverer is entitled to be classed among the greatest bene-"factors of mankind. But *the beneficent and imposing character of* "*the discovery cannot change the legal principles upon which the* "*law of patents is founded*, nor abrogate the rules by which judicial "construction must be given. These principles and rules are fixed, "and uninfluenced by shades and degrees of comparative merit.

"They secure to the inventor a monopoly in the manufacture, use
"and sale of very humble contrivance, of limited usefulness, the
"fruits of indifferent skill and trifling ingenuity, as well as of those
"grander products of his genius which confer renown on himself and
"extensive and lasting benefits on society. But they are inadequate
"to the protection of every discovery by securing its exclusive con-
"trol to the explorer to whose eye it may be first disclosed. A dis-
"covery may be brilliant and useful, and not patentable. No matter
"through what long solitary vigils or by what importunate efforts
"the secret may have been wrung from the bosom of nature, or to
"what useful purposes it may be applied. Something more is neces-
"sary. The new force or principle brought to light must be em-
"bodied and set to work, and *can be patentable only in connexion*
"*or combination with the means by which, or the medium through*
"*which, it operates.*"

Now, may it please the Court, that is a statement of a *limitation of patentability*, which by that time had come to be firmly settled in the law, a limitation which has its root in considerations of public policy,—that it is not the policy of the patent law, which, as the constitution expresses it, "is to promote *the progress* of the useful "arts by securing to inventors for a limited time the exclusive use "of their discoveries,"—it is not the policy of the patent law to allow a discovery, however brilliant, however beneficent, to be secured to the discoverer *otherwise than in connexion with the mode in which he has reduced it to practice and given it form.* Whether we like that limitation or not, whether we can make a good argument against it to-day or not, is of no consequence. That battle has been fought. That question is settled.

Now, as I conceive, the question of law which comes before the Court at the present time under that head is *in form* new. I cannot find any judicial decision in which it has been determined explicitly one way or the other. The question is this: Postulating that a man cannot have under our law a valid patent for a scientific discovery, but only for his mode of using it; is it not also true, by parity of reasoning and in deference to the same policy of the law, that he cannot have a patent for doing that which is intrinsically, of physical necessity, involved in the use of that discovery? Can he have a patent for the physical or scientific law which is involved necessarily in the use of that discovery at all? I will give an illustration: In the important case recently decided in the Supreme Court of *Tilghman* v. *Proctor*, or the *Fatty Acid* case, so called, wherein a very able opinion was pronounced for the Court by Mr. Justice BRADLEY, it was a fact, as stated in the opinion, that the physical law which underlies the use of water for the decomposition of fats into their components, acid and glycerine, is that you must combine an atomic equivalent of each of these substances with water. If you do that, you accomplish the decomposition; if you do not do that, you cannot accomplish the decomposition. It is the concrete statement of the abstract proposition of using water for decomposing glycerine. Now then, if a man could not have a patent for the use of water to decompose glycerine into its constituent fat and acid, could he, by changing the phraseology of his claim, cover that ground, substantially, by *claiming the combination of an atomic equivalent of each with water*, being that which necessarily takes place when glycerine is decomposed by the use of water? That is my difficulty in upholding this patent to the extent to which the claim of the plaintiffs in this case goes. The law is not satisfied with condemning the language of the claim. It condemns the substance and effect of it. I agree that in *O'Reilly* v. *Morse* the difficulty lay on the very surface of the claim itself. The inventor claimed *in terms* the use of electricity in transmitting messages to a distance. But the difficulty with his claim lay deeper than the language he happened to employ. The difficulty was not, as I believe my brother Storrow said it was, that Mr. Morse had not put into his specification that which he desired to claim. Suppose he had. Suppose he had made his claim thus: "I claim the "method of transmitting signals telegraphically by causing variations "of the electric or galvanic current corresponding to the signal sent, "and causing such variations to reproduce like signals at the receiv"ing station." Why, the answer to that would have been: "That is "what is essential and inevitable in, and inseparable from, the use of "electricity for the purpose of sending messages to a distance. You "have changed your words, but you have not changed your claim." The plaintiffs here are in that category. In trying to state a claim which shall be valid under our law and yet broad enough to cover the defendants' method, their argument betrays just this fallacy: the fallacy of confounding the statement of a problem with the solution of it; confounding the explanation of the character of the thing which must be done, if you propose to use a certain natural agent for a certain useful purpose, with *the mode of doing it*, — the mode of solving that problem.

Mr. Bell says, "I claim the method of transmitting vocal or other "sounds" (for our purposes, articulate speech) "telegraphically by "causing electrical undulations similar in form to the vibrations of "the air accompanying the said vocal or other sounds." That is the *statement* of the problem. He then adds the words, "substan-"tially as set forth." That refers us back to his specification to find out what *his solution* of that problem is. With that I am content. I am content to put this case upon the broadest, the most liberal, interpretation which we can give to his description of *his mode* of solving that problem.

I say the problem of all telephony, the problem of every possible use of electricity for the purpose of the transmission of speech, is that there shall be produced on the line electrical variations which correspond in form with the air-waves which have been produced by speaking, and that the act of speaking must, in some way, cause these corresponding electrical variations to be set up, and that the electrical variations must, in some way, cause air-waves at the receiving station like those at the transmitting station. If the patent of Mr. Bell be for *his way* of doing that, however broadly regarded (and it cannot be regarded too broadly, for Mr. Bell was the first in the field), I have no fears as to the question of infringement; no difficulty as to the construction of his patent in the fullest consistency with the decision of this Court in the case of Spencer. If it be a patent for producing such necessary undulations, and translating them into audible air-vibrations again, *no matter how*, it is such a patent as the policy of our law forbids that any man should have.

I think that there is no doubt, from the affidavits and upon the arguments in this cause, that the plaintiff puts his case, and must put it, upon just that fatally broad ground which I have indicated. He claims that we infringe upon his patent, because his patent is to be construed, can be and must be construed, and may legally be construed, to be a patent for producing upon the line electrical variations which correspond in form with the air-waves produced by speaking, the act of speaking in some way causing these corresponding electrical variations to be set up, and the electrical variations in some way causing air-waves at the receiving station like those at the transmitting station, *no matter how that is done.*

Now I want to read a few extracts from some of the affidavits. In the first place, I will read and quote from the plaintiff's brief in the Spencer case, used before this Court: He quoted Sir William Thompson, the famous scientist in this department upon the other side of the water, as saying that " Mr. Bell's invention realized *the* "*mathematical conception* that if electricity is to convey all the deli- "cacies of quality which distinguish articulate speech, the strength of " its current must vary continuously, and, as nearly as may be, in "simple proportion to the velocity of a particle of air engaged in "constituting the sound." That was a mathematical conception; a statement of the thing which you must find *a way to do* if you would telegraph speech. Mr. Bell, in his own affidavit in this case, says that before May, 1875, "he had perfectly satisfied himself that *the* "*electrical transmission of speech depended upon* producing upon the " line wire electrical undulations or variations which should cor- " respond in form to the aerial vibrations which constituted the sound "to be transmitted." Cross' affidavit in the present case says, "The "method of transmitting vocal and other sounds by a constant and "continuous control over the receiver, through a current which is " undulatory and continuous, and not intermittent or broken, and "which itself is produced or controlled by, and therefore conforms "to, the motion of the transmitter actuated by sound-waves, is "*essential to the transmission of speech.*" On the part of the defendant, Mr. Pope says, " *Speech cannot be telegraphed at all un-* "*less* electrical action of some sort is made to take place which cor-

"responds with the mechanical action of sound-waves, and which is "capable of producing a like mechanical action. *This is necessarily "involved in the use of electricity for this general purpose."* And there are more extracts on our brief which I will not stay to read.

Now I come to the only attempt which I can discern in the plaintiffs' brief to establish a middle standing-ground between the broad and untenable claim to the conversion of speech-vibrations into the necessary electrical undulations, and these again into audible air-vibrations, *in any way*, and the lawful claim to *Mr. Bell's way* of doing it. They take up this statement of Professor Trowbridge: "In "both the method of Dolbear and that of Bell, electrical variations "corresponding in form with the air-vibrations produced by the "utterance of speech, are set up in the line wire. Unless this is "done it is physically impossible that speech should be transmitted "by electricity." And they say (p. 57), "Mr. Bell, however, went "farther than this. He employed *the sound-waves themselves* to pro-"duce these electrical undulations." Is that a real distinction, or is it a distinction in words only? No human being has been found to say he believes it to be possible to set up these electrical variations, answering to the vibrations produced in the air by human speech, unless the speech is the agent for creating these electrical variations. The gentlemen say no other mode of transmitting speech electrically is known, and "perhaps," no other will ever be known. Is it trying the question fairly, may it please your Honours, to speak of *theoretical* possibilities? The question is a practical one. If your Honours see here a practical agreement of scientific men, with nothing that occurs to your Honours' own mind to control it, a practical agreement that if you give Mr. Bell the broad claim now made for him (which you must give him to hold this defence), you give him, *under another form of words, the monopoly of the right to use electricity for the transmission of speech*, I submit that you should hesitate to give him that claim.

Well, may it please your Honours, it is worth while, I suppose, in the case of even the greatest of inventions, to take a look at the inventor's patent. Because, giving him the largest and most liberal interpretation of it, we must after all look to see what he himself says was his invention, the thing which he desires to protect. Let us look at his patent, now, to see if we can find there any light upon this question whether *his mode* of setting up these electrical undulations, corresponding in form with the air-vibrations, is defined by him as *consisting in* doing it by the act of speech. That is the line to which plaintiffs come, and beyond which they refuse to come, in the direction of defining Mr. Bell's *mode of employing* the underlying physical law or mathematical conception.

Can it be properly said, may it please your Honours, that Bell's method of producing electrical undulations of the form indispensable to the transmission of human speech *consists* in causing these electrical undulations *by the voice*, no matter how? I respectfully submit that it cannot be said consistently with what *he* has said in his own patent. After describing various ways in which the armature at the transmitting end of the apparatus may be set in vibration, he comes to that part of the patent in which the *speech*-transmitting apparatus and method engage attention. Nobody has ever supposed, nobody has ever intimated, so far as I know, down to this time, that there was any mode of using electricity for the purpose of transmitting speech described in Bell's patent, except the mode which was embodied in the passage I am going to read, —giving to that passage, as I say again and again, the broadest, the most liberal interpretation possible under our law. Now, when he approaches that part of his patent, he begins thus: "One of the ways in which "the armature may be set in vibration has been stated above to be "by wind. Another *mode is shown* in fig. 7, *whereby* motion can be "imparted to the armature *by the human voice*, or by means of a "musical instrument." Clearly, he is going to describe to you a mode *whereby* the action of the human voice shall be made to set up the necessary vibrations. He goes on to describe, in the paragraph beginning, "The armature is fastened loosely by one extremity," his apparatus in fig. 7, his telephone, and it has been, as I understand it, the concurrent judgment of counsel and Court, up to this time, that *the functions involved in* that apparatus, *the things done* *by* that apparatus, broadly considered, constituted the method of Mr. Bell, — his method of causing the necessary undulations by the voice.

Now I have spread upon the brief, the part of which I wrote, a minute examination of the cases (from the Supreme Court, almost exclusively) upon the question commonly spoken of as the question of patenting a principle. I shall not detain the Court by reading what is there printed; only, as I pass over the pages, I soall, necessarily more or less discursively, allude here and there to matters which I find on the brief of the other side, touching the same cases.

Take first *O'Reilly* v. *Morse*. In the discussion of *O'Reilly* v. *Morse*, on page 47 of their brief, the plaintiffs call attention to the great weight of the dissenting opinion by Judge NELSON and Judge WAYNE and Judge GRIER. I do not think it necessary to talk much about the weight of dissenting opinions, considering that the doctrine dissented from has got itself by this time so firmly established. But I confess to a little surprise at finding on the brief an allusion to the caution to be observed in accepting *dicta*, coupled with a commendation to the Court's unreserved consideration of the dissenting opinion of *Mr. Justice* GRIER. For, if there was one judicial virtue which that eminent judge cannot be certainly said to have possessed, it was the virtue of circumspection and temperance of statement in the matter of dictum. In regard to the case of *O'Reilly* v. *Morse*, I find this, which bears a little upon the actual question we are discussing. They say that in the case of *O'Reilly* v. *Morse* the *fifth* claim was sustained, and that if the fifth claim was sustained, there is no reason why the claim of Mr. Bell, in the broad shape in which they present it here, should not be sustained. What the Court said was this: " We perceive no well-founded objection as to the first seven claims: the difficulty arises on the eighth." To "that extent, in that way, they sustained the first seven claims, saying nothing in particular about them and giving no reasons. The contest was over the eighth claim. But what was the fifth claim which was sustained; and does it bear any relation to a claim of the breadth of that which is made now for Mr. Bell, and which I am endeavouring to dispute? The fifth claim in *O'Reilly* v. *Morse* was this: "I claim as my invention *the system of signs*, consisting of dots "and spaces, and of dots, spaces and horizontal lines, for numerals, "letters, words and sentences, substantially as herein *set forth and* "*illustrated*, for telegraphic purposes." Now, can anybody say seriously that that sort of claim belongs in the same category with the broad claim of Mr. Bell we are discussing? And does it help the matter to use the illustration used on the plaintiffs' brief about Mr. Bell's "electric *alphabet* of articulation"?

[NOTE. — A point not on the plaintiff's brief, and not stated in the plaintiff's opening, was made in the closing argument for the plaintiff. It was that the *first* claim of the Morse patent (one of those which the Court sustained) was, in effect, as broad as the claim which we say Mr. Bell cannot lawfully hold; that it was, in effect, a claim to doing that without which the use of electricity for transmitting signals to a distance is physically impossible. We do not so understand the first claim. The opinion gives us no information whether the Supreme Court so understood it. The first claim says, "I do not claim the use of the galvanic current, or "current of electricity, for the purpose of telegraphic communications generally; "but what I specially claim as my invention and improvement is making use of "the motive power of *magnetism*, when *developed by the action of such current or cur-* "*rents, substantially as set forth in the foregoing description of the first principal part* "*of my invention*, as means of operating or giving motion to *machinery* which may "be used to imprint signals upon paper or other suitable material, or to produce "sounds in any desired manner, for the purpose of telegraphic communication at "any distances. The only ways in which the galvanic currents had been proposed "to be used, prior to my invention and improvement, were *by bubbles* resulting "from decomposition, and the action or exercise of electrical power upon a mag- "netized *bar or needle;* and the bubbles and deflections of the needles thus pro- "duced were the subjects of inspection, and had no power or were not applied to "*record* the communication. I therefore characterise my invention as the first "*recording or printing* telegraph by means of electro-magnetism. There are various "known modes of producing motion by electro-magnetism, but none of these "had been applied, prior to my invention and improvement, to actuate or give "motion to *printing or recording machinery*, which is *the chief point of my invention* "*or improvement.*"

The invention covered by the first claim, then, was the use of the motive power of *magnetism*, developed by *the electric current*, with *machinery* capable of producing *legible or audible* signals, as distinguished from merely *visible* signals. This was not a claim to monopolize the physical conditions necessarily existing in all cases of using electricity to transmit signals, whether general or particular. It was a claim for translating the signals communicated to the wire into such as should be audible or legible, instead of being only visible, and doing this by means of machinery controlled by *magnetism into which the electric current was first converted.*]

I do not find on the plaintiffs' brief any reference to the second of the two lead-pipe cases. The first of these two cases, *Leroy* v. *Tatham*, came up on law. The judgment for the plaintiff in the Court below before Judge Nelson was reversed. It was reversed upon the ground that, as the Court then construed the patent, the machinery was made a necessary element of the claim; and, as the machinery was old, the Court held the patent void. It afterwards came up before the Court again, in equity, and there the Court found their way to sustain the patent, but not in any such way as to touch the question with which we are now dealing. The decision passed upon this point, that, inasmuch as the inventor had discovered the scientific fact or law that lead, after melting and before it had become solid again, could, after separating, be made, under sufficient pressure, to reunite and become practically whole again, he was entitled to hold his patent for the old apparatus used for that purpose, as involving a *way* of applying that scientific law, although the apparatus had been used before for other purposes. The case is fully explained on pages 11 and 12 of our brief.

I refer to this second case of *Leroy* v. *Tatham* now, because it contains this sentence in regard to *Neilson* v. *Harford*, the hot-blast case, which figures so prominently in all discussions of this question. The Court say of *Neilson* v. *Harford*, "As no specification was "claimed in regard to the machinery, it is not perceived how the "patent could be infringed, unless upon the principle that, having "claimed no specific mode of applying the heat, he could use any "mode he might prefer, in defiance of the rights of other patentees. "*Now this cannot be law. Certainly it is not law under the Patent Act* "*of this country.*" We know that that was a misconception of *Neilson* v. *Harford*, as the Supreme Court afterwards declared that Neilson did not patent a principle, but the method of carrying it out. Still, speaking upon the hypothesis that having claimed no specific mode of applying it, he could use any mode he might prefer in defiance of the rights of other patentees, the Court do in fact say, "This cannot "be law. Certainly it is not law under the Patent act of this country." *And in that opinion Mr. Justice* Nelson *concurred.*

The case of *Neilson* v. *Harford*, the hot-blast case, is discussed upon the plaintiffs' brief. I wish to make a remark only upon one point of that discussion. The brief states that "it is a fact that no "man has been able to attain Neilson's results in a blast furnace "without blowing in hot air; and it is a matter of physical necessity "that this cannot be done unless the air be artificially heated between "the general atmosphere whence it is taken and the furnace where "it is to act, so that his patent was practically as controlling as if "for a principle." The inference intended is, that we are to take *Neilson* v. *Harford* as involving in the judgment rendered a decision to this effect: that a man *may* have a patent for the physical law which underlies his method and all methods for the use of a certain agency for a certain useful purpose. Now I conceive that to be a misstatement. Certainly nothing of the sort is hinted at in any of the opinions in *Neilson* v. *Harford*. Certainly no court in this country, commenting upon *Neilson* v. *Harford*, has ever taken any such view of it. I do not understand it to be true that it is a matter of physical necessity that you cannot avail of the advantage of using hot air in a furnace instead of cold air unless you heat the air artificially between the blast and the furnace where it is to act. I suppose you may have the blower, for that matter, *in* the hot-air chamber, heat your air in the chamber, and blow it from that to your furnace. The invention of Neilson, and the patent as finally sustained, were limited to the mode of availing of the benefits of hot air in a blast furnace, which mode consisted in interposing a heated receptacle between the blower and the furnace, and by this means heating the air *after* it left the blower, and *before* it reached the furnace.

I find on the plaintiffs' brief a reference to the case of *McClurg* v. *Kingsland*, 1 How. 202. I have no objection to that case. That was a plain case of a patentable and patented method. The method consisted in giving a particular direction to the tube which conveyed the metal to the mould, whereby the slag and other impurities of the cast would be thrown to the surface of the thing to be cast.

I have no objection, either, to the case of *Roberts* v. *Dickey*, decided at the Circuit Court by Mr. Justice STRONG, and discussed on pages 50 and 51 of the plaintiffs' brief. That was a patent for a method of increasing the productiveness of oil wells by causing an explosion of gunpowder, or its equivalent, substantially as described. I have a good deal of satisfaction, on the other hand, in the language used by Mr. Justice STRONG in the way of definition of the sort of patent a man *may* have when he has made an invention of that broad character. "Roberts," he says, "devised a mode of putting to prac- "tical account *a geological truth*." (In the case of Mr. Bell it is an electrical truth.) "Roberts devised a mode of putting to practical "account a geological truth, and *if the means he devised were novel,* "*if the process was the product of invention and was useful, it was* "*a proper subject for a patent.* The patent is not obnoxious to the "objection successfully made against the eighth claim of the Morse "patent in *O'Reilly* v. *Morse*. That was a claim for the use of the "motive power of the electric or galvanic current, however devel- "oped, for making or printing intelligible characters, signs or letters "at any distance. It was therefore a claim for a principle, — a nat- "ural law, — and *not for any particular method of applying it.*"

Now, may it please the Court, I have endeavoured to shew that whereas Mr. Bell cannot, under our law, have a patent for the use of electricity for transmitting speech; and whereas he cannot have a patent for doing that which must be done, in the nature of the case, as a matter of physical necessity whenever you *do* transmit speech electrically, because that is only another way of asserting the same unlawful claim; and whereas he cannot maintain, as a practical limitation of that dangerous ground, that his mode is the mode of producing the necessary electrical variations on the line *by* the act of speech, because that again is only an apparent limitation, and not a real one, — I now ask your Honours' attention to the question, what *is* that claim of Mr. Bell's, that broadest claim possible under the law, for a *mode* of using electricity for the purposes of transmitting speech? Let it be something which is consistent with the law, consistent with his patent, consistent with the history of his own actual invention; and, no matter how broad it is, no matter whether his claim hits or misses this or any other defendant, let us give it to Mr. Bell.

I must first discuss for a few minutes a view of the law which I find suggested here and there on the plaintiffs' brief, and which I deem to be unsound. It is, that whether we have regard to Mr. Bell's method or to his apparatus, each of the two being, as it is called, *generic*, that is, the first that ever existed which produced the result at all, he is entitled to hold as an infringer of the patent for that apparatus or for that method, as the case may be, any one who uses *any material part which is also new* of either the apparatus or of the method. That, I submit, is not law. I quite agree that where a patentee's method or his apparatus is the first that ever existed for the purpose of that result at all, that is what we call a generic invention. I quite agree that differences of construction between what it shews in the patent and what a defendant uses, would in such a case be rejected as immaterial; which same differences, if the extent of his novelty were less than that, might become material. But we must always come down to this question, — the question to be determined as favourably as possible for the patentee in each case, — we must always come down to the question what is *the substance of the apparatus*, and what is *the substance of the method*, which the patentee has provided for producing his result? He patents the apparatus or the method as he has put it together, as *his way of producing that result;* and you must find the substance of the whole of it, the substance, I say, of the whole of it, *all that is essential for the production of his result in his way*, discarding unimportant details, or you cannot find any infringement.

Now I am aware that Mr. Justice CLIFFORD did on one occasion say, in a charge to a jury, that patents for inventions might be divided into four classes, one of which, the last of which, was a patent for a combination, strictly so called; which by the way was the class to which the patent before him belonged, and on which it was sustained, and therefore the other three didn't seem to be of any particular importance in that case. The first one of his four classes of patents was a patent for "a machine," in other terms, we may say, a patent for "an apparatus," and that, he said, might be infringed by the use of any material part of it which was new. That case is not on the plaintiffs' brief; I hope for some credit for generosity in putting it at their disposal. That was the case of the sugar refinery, in which brother Smith and I worked in opposition to each other, as I remember to this day with no particular satisfaction. Now, if there was any one thing which Mr. Justice **Clifford** loved in his judicial capacity more than another, it was a general proposition. He loved to codify the law as he went along. He had no occasion in the case before him to set up this category of four kinds of patents and four kinds of infringement. He didn't make the least use of it in that case, nor has any judge made the least use of it or given the least recognition of it from that day to this, himself included.

Perhaps I cannot spend my time better than to make sure of our ground on this question of law, because it is an important one, and if the ground is well taken on the other side, it may affect your Honours' judgment a good deal. I say again that that dogma of Mr. Justice **Clifford** is one which he never himself applied to any judicial decision, nor did any other judge, so far as the records shew.

Mr. **Storrow.** — He applied it in *Howe* v. *Williams*.

Mr. **Browne.** — I shall come to *Howe* v. *Williams* directly. I want now to turn to those places in the brief of the other side, where my friends seek to find some support for that notion in certain cases they refer to decided by other courts.

First. They refer to the case of *O'Reilly* v. *Morse*. Speaking of the case of *O'Reilly* v. *Morse*, the brief says, the Court "are further "*careful to state* that the defendants' mechanism *may infringe, though* "*they do not copy the whole of the mechanism, nor employ the whole* "*of the process of the patents*." Now, if the Court said that, whether carefully or carelessly, we have got to take the consequences of it; but I think you will be as surprised as I am at this interpretion of the Court's language when you come to see what that language was. I will read it, and you will readily judge whether it supports any such notion. After quoting the eighth claim, the Court says, "It is impossible to misunderstand the extent of this claim. He claims the "exclusive right to every improvement where the motive power is "the electric or galvanic current, and the result is the marking or "printing intelligible characters, signs or letters at a distance. If "this claim can be maintained, it matters not by what process or "machinery the result is accomplished. For aught that we now "know, some future inventor, in the onward march of science, may "discover a mode of writing or printing at a distance by means of "the electric or galvanic current *without using any part of the process or combination* set forth in the plaintiffs' specification." Does anybody suppose the Court meant to lay down there such a doctrine as the brief asserts? They meant nothing in the world but a *reductio ad absurdum* of the 8th claim. They had no idea of saying that if a defendant *did* use "*any part*" of the process or combination, he would be liable.

The case of *Tilghman* v. *Proctor* is referred to on the plaintiffs' brief as lending some support to the doctrine in question. In that case the Court held that the patented process of Tilghman was not affected by the introduction of a new improvement in the process on the part of the defendant. I agree to that. That is one of the commonplaces of the law. One of the steps of the process may be improved and yet the essential character of the process, of *the whole* of the process, be preserved.

Now, says my brother Storrow, Judge Clifford applied his doctrine in the case of *Howe* v. *Williams*. Brother Storrow quotes the case of *Sanford* v. *Merrimack Hat Company*, 10 Off. Gaz., decided by Judge Clifford in 1876, where he repeats his category of four classes of patents (without, by the way, reasserting his rule of infringement); and then brother Storrow says, "Applying this rule to "a contest between Howe's patent and a sewing-machine," he decided so and so in *Howe* v. *Williams*. *Howe* v. *Williams* was decided in 1863, thirteen years before *Sanford* v. *The Merrimack Hat Company*, and half as many before the *Sugar Refinery* case to which I have referred. His Honour had not got to that point, by a good many years, when he decided the case of *Howe* v. *Williams;* and he did *not* in *Howe* v. *Williams* decide or allude to any such thing, as I will now make plain.

The claim in question — the great claim — was the forming of a seam under the combination and arrangement of parts substantially as described. That was held to be, first, a claim for an organized sewing-machine consisting of certain essential things, and, secondly, a claim for certain sub-combinations of details of the machine. Judge CLIFFORD dealt with the broad claim. Now the essential elements of the machine he found to be these; and as I read them, I will shew what he found about the defendant. First, he found that the two threads were interlocked *in substantially the same manner* in plaintiff's and defendant's. Secondly, he found that although the defendant did not use a shuttle which opened the loop as the Howe shuttle did, he used a hook which, co-operating with the needle, opened it in precisely the same manner as the shuttle, and that the hook, operating together with the needle, was *the equivalent* of the shuttle. In regard to the holding surfaces, the third important element, he found that the defendant had *the same, differing only in form.* As to the fourth and last of the essential elements, the feeding apparatus, he found that the feed used by the defendant *performed the same functions, had substantially the same mode of operation, and accomplished the same result.* The decision in that case was that the four great elements which went to make up the Howe sewing-machine and *enabled it to sew* were *all found, in form or substance, in the defendant's machine.*

There is a reference in the brief to the case of *Winans* v. *Denmead*, where the very able judgment of the Supreme Court of the United States was pronounced by Mr. Justice CURTIS. It has nothing to do, as I conceive, with this case. The patent was for making a coal car in the form of a truncated cone. The advantages claimed were, first, you could hang your car with its weight low, and you could enable the car to sustain the weight of the coal better. The defendant, instead of making his car a truncated cone, made it a truncated octagon. It was held to be substantially the same thing. There will be no dispute, I take it, about the righteousness of that judgment.

I do find in the decision of the Supreme Court in *McCormick* v. *Talcott*, 20 Howard, cited upon the plaintiffs' brief, a recognition of the one only true doctrine in regard to this matter of infringement of patents for generic machines or methods. The Court there say, "We must first inquire whether McCormick was the first to "invent the machine called a divider, performing the functions re-"quired, or has merely improved a known machine by some peculiar "combination of mechanical devices which perform the same func-"tions in a better manner. *If he be the original inventor of the ma-"chine* or device called the divider, he will have a right to treat as "infringers all who make" — what? Any essential new part of it? No. "All who make *dividers operating on the same principle and "performing the same functions by analogous means or equivalent "combinations.*"

The same principle is very forcibly stated in the case of *The Waterbury Company*, also on the plaintiffs' brief. In that case Mr. Justice **Woodruff** said that the machine of the plaintiff was "new "as a structure, new in its operation, and new in the effect produced. "The patent in such case is not for a mere combination. . . . "Another machine having the like construction, operation and effect "in *all that constitutes the principle of the machine and the efficient "means of its operation*, is an infringement of the patent, notwith-"standing, &c. . . . The complainant's patent is not strictly for a "combination, but rather for a machine, or a process wrought by a "machine. Like all machines, it is constructed by combining ele-"ments or details. In its distinctive features, as *a machine for the "purposes described in the claim and as a process of making kettles*, "it has been copied by the defendants. It embodies the principle, "process and substantial means which the Hayden machine embodies, "and *operates substantially in the same way*, though it may be less "perfectly."

The rule, then, in cases of a generically new machine or process, is, that if a defendant uses substantially *all the elements which the plaintiff uses to produce his result*, he infringes, although he may fail to use some mechanical details which the plaintiff uses along with those elements. There is no such law as that he may infringe by using a part only *of what is essential for producing the result.*

Now, may it please your Honours, I will ask you to look and see *what is Mr. Bell's described and patented method of transmitting speech.*

You will observe, in the first place, that it is a method of transmitting *speech*, not of transmitting electrical variations. Suppose he produce electrical variations upon the line, and suppose, for that matter, it be the same line and the same sort of current and the same electrical variations as those of the defendant; suppose he produce electrical variations *upon the line* by the action of his voice, and stop there? Those variations upon the line "die and make no "sign." They have not been converted into audible air-vibrations. That is not a method of transmitting *speech*. That is a method of transmitting vibrations from the air at one end to the thither end of the electric line, but as yet there is no mode of transmitting speech. There is none such till the speech uttered at the transmitting station becomes again speech audible at the receiving station. To do this, *the rest of the method* must be resorted to.

Now let us assume, for the purposes of this argument, that Bell's method of producing the necessary undulations in the line wire includes broadly causing the speech-vibrations of the air to act upon any instrument exposed thereto so as to produce variations of current corresponding to such speech-vibrations in the air. There are two questions: first, what is the character of the current in which he creates such disturbances or variations? That has been discussed by my brother Maynadier. I want now to discuss this question: *How does he say that such electrical variations on his line are to bring about the transmission of speech?* He tells us how he is going to convert the speech-vibrations into electrical undulations, but he must do more, or there is no method of transmitting speech. How, then, does he convert his electrical undulations into audible air-vibrations again?

Broadly, may it please your Honours, it is this — and I will try to demonstrate it in the little time I have left: He was dealing with the use of the known electric current, *flowing*, — to use a common, not very accurate, but not misleading, expression, — flowing through a circuit which embraced within it, at the receiving station, a soft-iron core around which the coils of that wire passed, and the current passing through the coils of that wire around that core made it an electro-magnet, whose magnetic condition varied according to the condition of the electricity on the line. Now, as my brother Maynadier said, speaking about Mr. Reis, whose name was first mentioned here in the opening argument for the plaintiff, we have no idea in the world of putting Mr. Bell here in the light of a mere improver upon Mr. Reis. We do not now refer to the Reis instrument as having been either in kind or in degree a speaking telephone at all. But we must take the state of the art of telegraphic transmission of *sound* as Bell found it, in order to form an intelligent judgment as to his invention, — as to what mode of using electricity for the transmission of speech he invented. Reis transmitted sounds over a telegraphic circuit by causing the air-vibrations to make and break that circuit at varying rates per second, so producing charges and discharges of the electro-magnet at the receiving station, and corresponding musical vibrations of a plate set up in the magnetic field. He did not, so this Court has decided, know or teach how to transmit articulate speech, and this for want of two things: first, a way of converting speech-vibrations into corresponding electrical variations, and, secondly, a way of reconverting such electrical variations into audible vibrations.

Now, what did Mr. Bell do? In the passage I cited here from his affidavit, we see plainly that he took the same electrical circuit with which Reis had been trying to deal, the only electrical circuit then known in the world, the only electrical circuit then supposed to be possible. This telegraphic circuit necessarily included a core around which the line wire was coiled at the receiving station, and which was made magnetic by the passage of the current around it as it traversed the circuit, and whose magnetic condition was made by Bell to vary in exact conformity with the electrical variations on the line wire, which again were in exact accordance with the variations of the speech-waves. Bell, then, was dealing with the known telegraphic circuit with its electro-magnet at the receiving station, *made* an electro-magnet by the current *flowing past* through its coils.

And here, I suppose, we strike the fundamental difference between the mode of using electricity as Mr. Bell does it and the mode of using electricity as Mr. Dolbear does it. Mr. Bell uses the action of *a current* of electricity which *by its passage* around a soft-iron core magnetises that core in degrees corresponding with the variations in *the current strength.* Mr. Bell uses, and must use, if there is to be an electro-magnet, a flowing current of electricity. The electro-magnetic action is only obtained through a flowing current of electricity. If the electricity with which Mr. Dolbear's condenser is charged shall be allowed to flow past it, if it shall not stay imprisoned there as a static force, his instrument is useless, his method is frustrated, it no longer operates. The passage of a current would be fatal to his method. It is because there is not and cannot be any current, that the electricity is stored up in his condenser-plate, the degree in which it is there stored or charged, the degree of tension which it exerts from instant to instant, being controlled in accordance with the speech-waves at the transmitting end. There is not, there cannot be, any current passing on through and beyond that condenser, as there is and must be a current passing on through and beyond the coils of the electro-magnet.

I conceive Mr. Bell's method of using electricity for the transmission of speech to be this; and I am quoting from the affidavit of a gentleman reputed to be one of the best electricians in this country, I mean Mr. Frank L. Pope: "The communication of phys-"ical motion from the air (by the act of speech) to the transmitting "diaphragm. 2. The production of electrical undulations in the con-"ducting circuit by the motion of the diaphragm. 3. The produc-"tion of varying degrees of magnetic intensity in the core of an "electro-magnet by the action of an undulatory electric current "traversing its enveloping coil. 4. The production of physical vi-"brations in a resonant plate by the varying magnetic attraction to "which it is subjected by the said electro-magnet. 5. The production "of sonorous [speech] vibrations in the atmosphere by the physical "vibrations of the resonant plate."

Now let us see how this matter has been handled heretofore; that is to say, in the Spencer case. I want first to say, that Mr. Bell's specification is in full accordance with the above definition of his method and in accordance with no other; secondly, I want to say that no other definition was involved in the decision by Mr. Justice Lowell in the Spencer case; nor do I think, I beg leave to say, that any other definition is consistent with the ground announced by his Honour in that case. First, as to Mr. Bell's specification: There is certainly not a word in it expressing or implying that he intended to use, or supposed it possible to use, any electrical circuit except the well-known one with its receiving electro-magnet. In the only places in which he does describe what is at the receiving station, he describes an electro-magnet with its armature vibrating in correspondence with the sounds transmitted.

Next let us come to the Spencer case. That is the only decision which has ever been made on the merits of the Bell patent, and of course it is of very great importance that we should rightly read it at the present time. In the first place, no such question, — I think his Honour, Mr. Justice LOWELL, will agree with me, — no such question as we have to deal with here appeared above the horizon in the Spencer case. The Spencer telephone had at the receiving end the electro-magnet, through the coils of which the electric current passed; it had at the transmitting station, — as his Honour decided, and it seems to me correctly, — one of the modes of converting speech vibrations into undulations on the line, which was explicitly mentioned by Mr. Bell in his patent. It was the effort of the defendant's counsel in that case, by putting on his legs Mr. Philip Reis as a person who had done something in the art of telephony, to abridge Mr. Bell's broad domain as the first producer of a telephone. In that he failed. Failing in that, — a defence which *we* do not touch at all, — failing in that, he was manifestly helpless. He had one of the modes of transmitting specially mentioned by Bell in his patent; he had Bell's line; he had Bell's current; he had at the receiving end the soft-iron core around which that current passed through the coils, just as it was described in Bell's patent, and the only thing for performing that part of the method which *is* referred to in Bell's patent.

As to the Spencer case, may it please your Honours, I would like to call your attention to the way in which this invention of Mr. Bell's was put to the Court; not that I wish to convict counsel of inconsistency, — that is a small business at the best, — but because the way it was argued to the Court may help us to throw light, where we need it, upon the view of the Court, to be ascertained from its opinion. What was said in the argument for the plaintiff as to the ground upon which Mr. Bell's invention should rest was this:

"His [Bell's] invention set forth in the claim 5 may be described "as follows: 'provide at the transmitting station a diaphragm or "'plate so sensitive that, when spoken to, it will take up from the "'air all the character of the air-vibrations with fidelity. Provide "'*at the receiving end an electro-magnet and an armature* which "'is capable of the same motion as that taken up from the air by "'the transmitter, and which has surface enough to impart those "'motions to the air. Obviously if this diaphragm (the armature "'of the electro-magnet) can be compelled to copy the motions of "'the diaphragm of the transmitter in all its characteristics, then the "'same sound which is uttered against one, and actuates it, will be "'heard to proceed from the other.' *Could a method of employing "electricity be discovered which would accomplish this result,"* — that the variations in *the electro-magnet at the transmitting station*, produced by the act of speech, should be copied by *like variations in an electro-magnet at the receiving station*, and there converted into speech-waves?

It was no great limitation to take that ground; because till long after Mr. Bell's patent, till this discovery of Mr. Dolbear's, nobody had supposed, as my brother Maynadier has repeatedly said, that there was or could be any electrical circuit, except that through which a current of electricity flowed through coils around a soft-iron core at the receiving end, the variations of whose magnetic condition gave you your means of producing signals there. Plainly, I submit, then, the Bell method was a method of *producing magnetic variations and consequent speech-vibrations* at the receiving end, similar to the speech-vibrations at the transmitting end, by means of electrical undulations produced on the line by the action of the speech-waves.

I think I can shew that no other view was taken by his Honour Mr. Justice Lowell in deciding the *Spencer* case. And perhaps I ought to say as much as this: Coming here to resist this motion for interlocutory injunction, — and an interlocutory injunction may ruin a defendant, and therefore it is accustomed to be regarded, I think, by the Federal judges as under some circumstances of as great gravity as, perhaps of far greater gravity than, some other cases which happen to take the shape of a final hearing, — coming here to resist this motion, we have got to make our peace, first of all, with Mr. Justice Lowell's decision. That decision of this Court is, as we say of commercial paper, good for its face; not to be impeached, not to be criticised, not to be doubted, for any purpose of this present motion. And if it shall appear to this Court that the injunction now asked for cannot be granted, that the ground now assumed by the plaintiff cannot be accorded to him, without the Court's occupying ground materially in advance of, and materially different from, the ground it occupied in the Spencer case, it seems to me, your Honours, that the defendants ought to be regarded here as litigating, not an old question, but a new question, and as entitled to all the advantages, whatever they may be, of being allowed to litigate it in the usual way, with the usual opportunity for cross-examination of witnesses.

Now I should like to read a little from Judge Lowell's opinion. He says, "The *invention* is nothing less than the transfer to a wire of "electrical vibrations like those which a sound has produced in the "air. The *claim* is not so broad as the invention. It was undoubt"edly drawn somewhat carefully, in view of the decision in *O'Reilly* " v. *Morse*, and covers the method and apparatus, that is, *any method* "*and any apparatus of substantially similar character to those de*"*scribed*. The patent points out distinctly that the undulations may "be produced in other modes besides the vibration of an armature in " front of a magnet; and the defendants make use of a mode not wholly " unknown at that time, though much improved, in creating their "undulations." That is, the defendants substituted for the armature one of the things, in substance, mentioned in Mr. Bell's own patent, which the Court held to be, for the purposes of that case, substantially the same as Mr. Bell's.

The Court held that it must find in the defendant's telephone not *some* method, but *Mr. Bell's method*, of using electrictity for the transmission of speech. It traced that method through, first, the production of undulations answering in form to the speech-vibrations; second, the transmission of them to the receiving station; third, the retranslation of them there into speech-waves. There was no question as to the third step of the method, or as to the second; the defendant had them literally. As to the first, his Honour held that, as to the means of bringing about the electric undulations by the speech-vibrations, the means used by the defendant was one of those referred to in Mr. Bell's patent, that is, by varying the resistance of the circuit. That was one alternative method of doing it recognized by Mr. Bell; therefore the change made by the defendant in that respect did not take him out of the liability to infringement.

Bearing in mind that when speaking of *the means of converting speech-vibrations into electrical undulations*, the Court expressly says that Bell could not (under *O'Reilly* v. *Morse*) cover *all modes* of doing that, but only his described mode and such as were substantially the same, we have now to apply the same rule to *the means of converting the electrical undulations into speech-vibrations again*; for until this is done, no transmission of speech is accomplished. According to Judge Lowell's decision, Mr. Bell cannot cover all modes of doing this, — of reconverting electrical undulations into audible air-vibrations; he cannot cover all modes of doing it, but only his described mode or such others as are substantially the same. We have seen that the only described mode was by causing the current which traverses the telegraphic circuit to produce in the electro-magnet, by passing through its coil, *magnetic variations* corresponding with the electrical undulations in the line wire. The question now is, whether Mr. Dolbear's method of converting electrical undulations in the line wire into speech-vibrations is substantially the same as that.

In the case of Mr. Bell there are electrical undulations produced upon the line. That is a part of his method of transmitting speech, but it is not of itself his method. What does he do with them? How does he proceed to convert these electrical undulations on the line into audible speech-vibrations? Why, sir, having certain electrical undulations, having undulations in an electrical current, he causes that current to pass through the coils which surround a soft-iron core and make that core an electro-magnet. That is *a step in Mr. Bell's method; one of the things which he does in order to work out his result,* — which thing is *not done at all in the Dolbear instrument.* There is no electro-magnet at the receiving end, or any equivalent or substitute therefor. That operation of converting the undulations on the line, first, into magnetic variations at the receiving station, and then using these magnetic variations to vibrate the diaphragm so as to make the sound audible at the receiving station, — that is a thing which is *not done at all by Mr. Dolbear.*

At the time of Mr. Bell's invention and patent, neither he nor any other man on the broad earth supposed that it was possible, having got the required electrical undulations on the line, to turn them into audible air vibrations at the ear of the listener, except by first converting these electrical undulations into variations in the energy of the electro-magnet, and using that magnet to operate upon the plate which was to vibrate and make the audible sounds. Now, there is no good reason why Mr. Bell, although having made a great discovery, as he did, having advanced the art of the use of electricity enormously for the benefit of the world, should be held to cover a mode of transmitting speech by electricity which *takes out of his mode one of its essential elements,* dispenses with it altogether, by virtue of the discovery of *a new way of using electricity,* a way which, at the time of Mr. Bell's patent, nobody supposed to be practicable.

I read, at the request of my colleague, two paragraphs from our brief, which contain all that the Court will probably require in answer to the question which was put to me when I began to speak, in regard to the two kinds of electrical action employed by Bell and Dolbear, respectively.

"To sum up, both methods are the same, up to and including the "magnetic variations at the sending station; but in Bell, the energy "of these magnetic variations is converted into electricity of the "lowest possible electro-motive force; the line has the lowest pos-"sible resistance, the dynamic property of the electricity alone is "utilised, and utilised by conversion into magnetic variations at the "receiving station. In order to be so converted, it must flow "spirally and many times around a magnet, and into ground or some "other reservoir. The potential is at the maximum at the ends of "the coil, and can never be greater than that due to the resistance "of the line, which must be as small as it can be practically made, "to give the best effects.

"In Dolbear, the energy of the magnetic variations must be converted into electricity of very high electro-motive force, enormous "in comparison with anything ever found in any practical Bell line. "The resistance of the line must be practically infinite. The dynamic "property of the electricity is very trifling, and not utilised at all; "there is no conversion of electricity into magnetic variations, nor "any flowing of it in a spiral, nor anything at all resembling this. "Its static properties only are utilised, and it acts by its mere "presence, under sufficient tension, at the plates of the receiver. It "is forced into these plates, but does not flow beyond them. There "is nothing in Dolbear's at all resembling the ground, or its equivalent, the ring circuit, essential to the proper operation of Bell; and "the presence of any such thing in the Dolbear line would wholly "prevent its operation. The potential at every point in the Dolbear "line is the same as the potential at the end of the coil with which "the line is connected, and the resistance must be enormous, and it "is better to have it infinite."

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY

v.

AMOS E. DOLBEAR ET AL.

HEARING ON MOTION FOR PRELIMINARY INJUNCTION.

CLOSING ARGUMENT OF CHAUNCEY SMITH FOR PLAINTIFFS.

CHAUNCEY SMITH,
JAMES J. STORROW,
for Complainants.

BOSTON:
ALFRED MUDGE & SON, LAW PRINTERS, 34 SCHOOL STREET.
1882.

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CLOSING ARGUMENT OF CHAUNCEY SMITH, ESQ., FOR PLAINTIFFS.

ON MOTION FOR PRELIMINARY INJUNCTION.

May it please the Court, — I think the counsel for the plaintiffs have reason to congratulate themselves upon the progress which the defendants' counsel have made in relation to this invention. Mr. Maynadier, speaking for himself, as I understand, and Mr. Browne, took occasion very early in the course of his argument to state that they fully admitted that Mr. Bell was the inventor of the speaking telephone, and entitled to great credit for it; and their brief raises no question as to that fact, nor as to the fact that the apparatus described in his patent will do what it purports to do. Three years ago I was engaged in a controversy over this same patent with Mr. Browne, in which he strenuously claimed that Mr. Bell was not the inventor of the speaking telephone, but that various other persons, including Mr. Dolbear himself, were the inventors; and he alleged and attempted to prove that the instrument described in Mr. Bell's patent would not work as he said it would. He has got past that now; and if he continues to make progress in the same direction hereafter as he has heretofore, he will be in full accord with us long before this case can reach Washington. Mr. Browne took occasion to suggest that the decision in the Spencer case was the only decision which had ever been had in relation to this patent upon the merits. I think not. I think that the conclusion to which the defendants' counsel have come, that Mr. Bell is the original inventor of the telephone and that the instrument he describes will work, is to be taken as a decision upon the merits, for nothing else would have brought these gentlemen to this conclusion.

The question which we are to consider here, may it please your Honors, and which this court must ultimately decide, is not whether Mr. Dolbear has made a patentable invention, — some invention which is so substantially different from Mr. Bell's that he is entitled to a patent; for all that may well be and he have simply improved the instrument. The question to be discussed and decided is whether, in using the instrument which he calls his telephone, he is using Mr. Bell's invention. And that is the only question. One year ago, in this court, I undertook to characterize the speaking telephone by the functions which it performs and the work which it does. I said: "This invention is distinct from all other inventions which preceded it, in the character of the work which it does and the way in which it performs that work." I alluded to the fact that the apparatus consists of two parts, each having a distinct function, — the transmitter and the receiver. I said that these two functions were analogous to the functions of the ear and tongue; that the speaking telephone was a listening ear and a speaking tongue, and it was by virtue of its possessing those two functions that it became what it was; that it was by virtue of the fact that Mr. Bell gave the instrument those two functions that he had made the speaking telephone.

Well, there is no question that Mr. Dolbear's instrument does the same work as Mr. Bell's, and has the two parts, a transmitter and a receiver; that the two parts of his apparatus have those two functions; that his apparatus is a speaking telephone by reason of the fact that it has those two functions, never possessed by any instrument before Mr. Bell's invention. Mr. Dolbear in his affidavit talks of his telephone. He has made some change in the apparatus for transmitting speech, and by reason of that change he speaks of *his* telephone. But the change he has made in the telephone would not of itself make that instrument or any other instrument a telephone. His receiver talks, not by reason of what he has done in substituting a plate, into and out of which electricity flows incessantly when it is at work, for a coil of wire through which electricity flows; it performs the function of talking because it has impressed upon it that which Mr. Bell did, and nothing else. He confessedly, as I understand it, started with a Bell telephone in his improvements, and when he had made them he hadn't anything but the telephone. He began with a telephone and he ended with a telephone, — only this and nothing more.

Suppose he had taken his receiver, when he had invented it, and put it, not with what Mr. Bell describes as his invention, but with that instrument which came nearer to the telephone than any other before Mr. Bell's, — the Reis instrument, — and had used it in connection with the Reis transmitter, as Reis directed it to be used: would he have had a speaking telephone? Whatever there may be in his instrument which makes it a speaking telephone he didn't put there himself; he didn't take it from Mr. Reis; he took it from no other person than Mr. Bell. The thing in it, whatever it may be, which makes it talk, was that which Mr. Bell instructed the world should be put into an instrument in order to make it talk. Suppose Mr. Dolbear had not only taken out of his receiver the electro-magnet, which Mr. Bell did not invent, but had taken out from the rest of the instrument that which Mr. Bell certainly did invent; suppose he had conscientiously excluded from his apparatus that which he knew Mr. Bell invented, — a means for impressing a certain character upon a current of electricity: would he have had a speaking telephone then? Isn't it because he did not exclude from his apparatus that which Mr. Bell instructed him and the rest of the world to use, that his instrument retained the character of a speaking telephone and the ability to perform that work?

I submit, may it please your Honors, that this covers the whole ground; that Mr. Dolbear has a speaking telephone because he retained in it that which he found in it and which Mr. Bell put there.

But Mr. Browne argues strenuously — and that is the only argument really upon the facts which he does urge — that by reason of the substitution, for the electro-magnet in the receiver of the Bell instrument, of a plate which, when charged with electricity and that charge constantly varied in accordance with the law which Mr. Bell laid down, will cause the diaphragm of his instrument to move as Mr. Bell said it would move, and therefore talk, — that by reason of that change he does not take Mr. Bell's invention, that he does not do in his receiver what Mr. Bell did in his receiver. Let us see! Let us see what Mr. Bell says does take place in his receiver, and by what agency. After describing the apparatus for producing undulations in a current of the character which he sets forth as essential, he says: "The *undulatory* current, passing around the electro-magnet, *influences* this armature to copy the motion of armature C," which is the armature of the transmitter. To what does he attribute the duty of *influencing* the armature to do its work except to the undulatory current? Not simply because it is a current, but because it is a current of a peculiar character. By virtue of that peculiar character it makes the armature perform peculiar motions, and thus makes the instrument speak.

Now, what is the fact in Mr. Dolbear's instrument? This changing current in his instrument, this changing amount of electricity, which is changing because it constantly flows into and out of the instrument under the control of a transmitter actuated by sound waves, *influences* the armature or the diaphragm of his instrument to do exactly what the current in Mr. Bell's instrument does, — to copy the motion of the transmitting instrument. It is the peculiar character of the changing amount of electricity in the two instruments which makes the armature perform the motions required of it, and through which motions the instrument talks. Now, I submit that when Mr. Dolbear makes the electricity flow into and out of his instrument according to the law which Mr. Bell described, and by reason of its flowing in that way *influences* his diaphragm to copy the motions of the transmitting instrument, he does in substance what Mr. Bell does when he says that the undulatory current flowing through the electro-magnet *influences* the armature of the receiver to copy the motions of the other armature.

He resorts to the same agent to exert the same *influence*. He gives to that agent the peculiar character by which alone it can perform the required duty, and which he was instructed to give to it by Mr. Bell.

Why, what is the fact? It is the varying amount of electricity present in each instrument at each instant, and varying at each instant in accordance with the law which Mr. Bell pointed out, which gives to the instruments, not the attraction upon the armature, — that had been given long before, — but the peculiar movements which are a copy of the movements of the transmitting armature. The *influence* of the electricity flowing into and out of the receiver is the *influence* which Mr. Bell resorts to — for in his instrument it flows in both directions alternately — to make the armature copy the motions of the transmitting instrument. Now, does not Mr. Dolbear take the substance of what Mr. Bell describes as the function of his own receiver, the talking function, when he makes the electricity in it vary in amount, just as Mr. Bell told him to do, and gets from it that peculiar influence which Mr. Bell has given to an electric current? I submit, may it please the Court, that he does do in substance just what Mr. Bell does, what Mr. Bell directed him and the world to do, when he directed the world to send through the receiving instrument an undulatory current which should exert an *influence* upon the armature of a peculiar kind, and thus give it the ability to speak.

Now let Mr. Dolbear leave out of his instrument that constantly changing current of electricity, changing in accordance with the law which Mr. Bell laid down, and tell me if he will have a speaking telephone. Let him eliminate from his apparatus the peculiar influence of the undulatory current described by Mr. Bell, and then see if he will have a speaking telephone. Why, his receiver even is not a telephonic receiver by virtue of what he did to it, but by virtue of what he has taken from Mr. Bell; and the evidence of that is, that if you connect it with any instrument which sends a current through intermittently, as the Reis instrument did, or as the Morse transmitter does, it would not be a talking instrument, because such a current would not influence the armature of the diaphragm in the way in which it must be influenced to take up the motions which it must have in order to perform the function of speaking.

Another ground of defence is that Mr. Bell's patent is not a good patent. I am not quite sure, and I haven't been quite able to determine, that the defendants do not mean to say that the invention described in that patent is not an invention which is capable of being patented. Mr. Browne says, if I understand him, you cannot have a patent for transmitting speech telegraphically. Why not? Wasn't it a new thing to do at the time Mr. Bell did it? Wasn't it a useful thing? This invention, so adapted to human wants, so simple in its character, so wonderful in what it accomplished that the world stood aghast when it was announced, has spread itself over the world with such rapidity that it is hardly an exaggeration to say that "there is no speech nor language where its voice is not heard." Isn't there utility enough in that, and wasn't there invention enough in that, to make it a patentable invention? Do I need to say anything more than to say that it did a useful thing which no man had ever done before, to show that it was a patentable invention?

Well, has Mr. Bell got a good patent for it? That depends upon whether he has complied with the statute requirements to secure his invention. It is not enough that a man shall make an invention to be secured in the use of it. He must do certain other things which the law prescribes, and those things are: That he must make application to the Patent Office for a patent, and with that application describe the invention, which he says he has made, so that other people can make it after him. And he must do a little more: he must, in the language of the statute, "in case of a machine, describe the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions." Well, now, it is admitted here that Mr. Bell did describe an apparatus so that other people can make it, and make it do the work which he assigned to it. So far, he has complied with the statute. And didn't he comply with the statute in pointing out the principle which distinguished it from all other inventions; when he said it must embrace this principle, that the current of electricity in it must have the form of the sound waves which fell upon the instrument? Wasn't that an announcement of its principle? didn't he then fully satisfy the conditions of the statute? Didn't he make a good invention and describe it well, and point out the principle which distinguished it from other inventions? I submit that he did.

And when he has pointed out that principle, he has a right to appeal to it to see whether another subsequent invention contains that principle or not. The thing which the statute required him to point out as the condition upon which he could have his patent, is the thing which he may resort to to determine whether another man has taken that which he invented. Well, it is admitted here by Mr. Dolbear himself that this statement of the principle of this invention involves what is absolutely necessary to any and every machine to make it a speaking telephone, and that his apparatus embraces that principle. He admits that he cannot make a speaking telephone which shall not involve that principle, which Mr. Bell announced in his patent as the one which distinguished his invention from other prior inventions. I submit, therefore, may it please your Honors, that Mr. Bell has not only made a great and useful invention, but has complied with the conditions of the statute in order to secure it; and he has a right to treat any other man as an infringer who employs the principle which he said characterized his apparatus and distinguished it from all prior inventions. And it is not denied here that Mr. Dolbear does that.

Mr. Browne has appealed to certain cases which he seems to think lay down some principles of law which, if applied to this case, will show that Mr. Bell's patent is not a good one, or that the thing which he claims as characterizing his invention could not be made the subject of a patent. And one of the cases which he refers to on his brief, page 15, is the case of *Morton* v. *The New York Eye Infirmary*, which is known as the "ether case," where the Court, in the very extracts which Mr. Browne has inserted in his brief, lays down certain principles as to what a man must do in order to make a patentable invention, and which they said Mr. Morton didn't do. Before reading that, let me say that Mr. Morton's claim was in substance for an improvement in the art of surgery by the use of ether, to produce insensibility in the subject of surgical operations. Mr. Morton did not invent or discover ether; he did not invent or discover any mode of producing it. He was not the first man who inhaled it or gave it to some other man to inhale; he was not the first man who discovered it would produce certain peculiar effects upon the human system. He only discovered that if you had a little more of those effects by taking a little more of the ether, you could then perform a surgical operation on the man without his being sensible of it. Whatever may be said about the patentability of that, Mr. Morton had done very little. Why, he hadn't done as much as the Chinaman had who first discovered that roast pig was good to eat. He didn't catch the pig, he didn't roast it, he wasn't the first man who tasted it.

Now, the passage which Mr. Browne has quoted is this: "In its naked, ordinary sense, a discovery is not patentable. A discovery of a new principle, force, or law operating, or which can be made to operate, on matter should not entitle the discoverer to a patent. It is only when the explorer has gone beyond the mere domain of discovery and has laid hold of the new principle, force, or law, and connected it with some peculiar medium or mechanical contrivance by which, or through which, it can act on the material world, that he can secure the exclusive control of it under the patent act." Didn't Mr. Bell do exactly that? Didn't he not only discover some law or principle, but connect it with some peculiar medium or mechanical contrivance by or through which the contrivance would talk? That is the difference between the ether case and this. Mr. Bell not only discovered a principle, but he connected it with a mechanical contrivance which enabled the principle to become effective. But I proceed with the reading: "He then controls his discovery through the means by which he has brought it into practical action, or their equivalent, and only through them. It is then an invention, although it embraces a discovery. Sever the force or principle discovered from the means or mechanism through which he has brought it into the domain of invention, and it immediately falls out of that domain and eludes his grasp. It is then a naked discovery, and not an invention. Every invention may, in a certain sense, embrace more or less of discovery, for it must always include something that is new; but it by no means follows that every discovery is an invention. It may be the soul of an invention, but it cannot be the subject of the exclusive control of the patentee or of the patent law until it inhabits a body, any more than a disembodied spirit can be subjected to the control of human laws."

Well, didn't Mr. Bell not only discover a principle but provide a habitation for that principle, in which it might dwell and through which it might do its work? I ask your Honors' permission to read in connection with that, though not as authority, a statement by an eminent jurist of what I understand the patent law to be, better than I could give if I took more time even than I have at my command. It is from the dissenting opinion of Mr. Justice Nelson, in the case of *Leroy* v. *Tatham*, 14 How. After discussing the cases which had arisen he says, page 186: "The settled doctrine to be deduced from them, I think, is, that a person having discovered the application for the first time of a well-known law of nature, or well-known property of matter, by means of which a new result in the arts or in manufactures is produced, and has pointed out a mode by which it is produced, is entitled to a patent; and if he has not tied himself down in the specification to the particlar mode described, he is entitled to be protected against all modes by which the same result is produced by an application of the same law of nature or property of matter: and *a fortiori*, if he has discovered the law of nature or property of matter, and applied it, he is entitled to the patent and aforesaid protection.

"And why should not this be the law? The original conception, the novel idea, in the one case is the new application of the principle or property of matter, and the new product in the arts or manufactures; in the other, in the discovery of the principle or property, and application, with like result. The mode or means is but incidental, and flowing naturally from the original conception, and hence of inconsiderable merit. But it is said this is patenting a principle, or element of nature. The authorities to which I have referred answer the objection. It was answered by Chief Justice Eyre, in the case of Watts's patent, in 1795, eighty-seven years ago; and more recently in still more explicit and authoritative terms. And what if the principle is incorporated in the invention, and the inventor protected in the enjoyment for the fourteen years? He is protected only in the enjoyment of the application for the special purpose and object to which it has been newly applied by his genius and skill. For every other purpose and end, the principle is free for all mankind to use. And where it has been discovered, as well as applied to this one purpose, and open to the world as to every other, the ground of complaint is certainly not very obvious. Undoubtedly, within the range of the purpose and object for which the principle has been for the first time applied, piracies are interfered with during the fourteen years. But anybody may take it up, and give to it any other application to the enlargement of the arts and of manufactures, without restriction. He is only debarred from the use of the new application for the limited time, which the genius of others has already invented and put into successful practice."

Now, in this case Mr. Bell has described a principle or mode of operation to be embodied in a machine for the purpose of transmitting speech, and for that purpose he is entitled to the monopoly of it, however that principle is carried out, so long as it is the soul of any other instrument, and determines its mode of operation to produce that result.

My brother Browne says this cannot be in the case of the telephone, because there is no other way in which you can make a telephone! and he says we *now* admit it. We always admitted and claimed it. What of it? What if nature has provided but one principle by which this work can be done? Isn't the man who dragged that principle to light and yoked it to human wants entitled to the benefit of it as much as if there had been a dozen ways of doing it? Why, the difficulty of the discovery and the merit of the discovery is greater if it can be done only in one way than it would be if it could be done in a dozen ways.

GRAY, J. — Didn't you mean to say one method rather than one principle? Didn't you mean to say if there was only one method in which it could be applied?

Mr. SMITH. — That is what I meant. Mr. Justice Nelson, at the conclusion of his opinion, says that he does not understand that the Court dissented from his view of the law, but only from his application of the principles of law which he laid down to that case. And a few years afterwards the Court held that that patent was a good patent, and I suppose upon the very ground which Mr. Justice Nelson had indicated.

Mr. Browne in his brief has referred to the case of *O'Reilly* v. *Morse*, where this matter is discussed, and where, as I understand the opinion, the Court drew just that distinction between patenting a principle of itself and alone, and the patenting of a principle when it had become embodied by the inventor in some material form. But Mr. Browne puts this case: "Suppose," he says, "the claim had been the method of transmitting signals telegraphically by causing variations of the electric or galvanic current corresponding to the signal sent, and causing such variations to reproduce like signals at the receiving station: such a claim would have been void for the same reason that Morse's claim was held void." Was it so? Why, in point of fact there was a claim in that patent which the Court held to be valid, which was almost in the same form suggested by my brother Browne, and of the form of the claim in Mr. Bell's patent. The first claim (page 85) was this: —

"*First.* Having thus fully described my invention, I wish it to be understood that I do not claim the use of the galvanic current or current of electricity, for the purpose of telegraphic communications generally; but what I specially claim as my invention and improvement is making use of the motive power of magnetism when developed by the action of such current or currents, substantially as set forth in the foregoing description of the first principal part of my invention, as means of operating or giving motion to machinery which may be used to imprint signals upon paper or other suitable material, or to produce sounds in any desired manner for the purpose of telegraphic communication at any distances."

Here there was a claim which the Court held to be valid, which was in substance for imprinting signals and producing sounds to make signals by the use of electro-magnetism developed by the action of an intermittent current; and all we claim is that we shall have this use of the peculiar electric current developed in the manner described by Mr. Bell, for doing the work which he has showed could be done by it, — for influencing by its peculiar character the diaphragm of the receiver to copy the motions impressed by sound waves on thetransmitter.

On page 6 of the defendants' brief, I find the following: —

"The plaintiffs' brief in the Spencer case quotes Sir Wm. Thomson as saying that Mr. Bell's invention *realized* the *mathematical conception* that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must *vary continuously and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sound.*

"This is just the special character of current variations which Mr. Bell claims the monopoly of producing by means of the sound waves.

"And Sir Wm. Thomson says that it is a mathematical conception of what must be done, *a statement of the problem.*"

The restatement by the defendants' counsel of what Sir Wm. Thomson said, changes the statement. Sir Wm. Thomson did not say that Mr. Bell's invention is a mathematical *conception* of what must be done, a *statement* of the problem; what he did say was that it *realized* a mathematical conception, — in other words, that it was a solution of the problem involved in the mathematical conception or in the statement of it. It was because Mr. Bell realized the conception by embodying it in a material apparatus that he made the invention; he did something more than state a problem;

he solved it by giving the world an apparatus which transmits speech.

One thing more, may it please your Honors, and I will close. On page 37 of the brief, Mr. Browne puts a case which he seems to think unanswerable, — a test case. "Bell," he says, on page 37 of his brief, "seems to have been the first to clearly apprehend the physical law which must be followed in the construction of a telephone to transmit speech by electricity, — viz., that the energy of the speech waves should first be in some way converted into a continuous current of electricity of the necessary strength to reproduce them, varying from moment to moment just as a particle of air in the speech waves varied from moment to moment; secondly, that this varying current must in some way be used to produce speech waves like the first. But this did not entitle him to a patent under our laws. In order to entitle himself to a patent, he had to devise a method of and apparatus for converting the energy of the speech waves into this varying current, and a method of and apparatus for reconverting this varying current into speech waves like the first." Didn't he do it? "Had he proceeded no further than the first step, — viz., devising the apparatus for converting the energy of the speech waves into this varying current, — it is submitted that he could not have had a valid patent; because he had accomplished nothing up to that time except of a purely scientific value. To test this: suppose he had obtained a patent stating in substance that he had discovered the law under which all must work who desired to make electrical speaking telephones; then given a clear statement of that law and then a clear explanation of his method and apparatus for converting the energy of the speech waves into electric undulations like in form to the speech waves; and after that had stated that he had not, up to that time, been able to devise any means for utilizing these electric undulations, but was devoting himself to that end, and hoped to be able at some time to accomplish it; and thereupon claimed: first, all electric speaking telephones made in accordance with that law described by him; and secondly, the method," etc. And he submits that Mr. Bell, in that case, could not have had a valid patent. Very likely. When a man comes into the Patent Office with an invention, no matter how large the invention may be, stating that it is not useful, I suppose he cannot get a patent for it, because one of the conditions of the law is that he shall not only make an invention, but it must be a useful invention. But as suming as Mr. Browne does that Mr. Bell had not invented a receiver at all, but had said, in an application for a patent for his apparatus for converting the energy of speech waves into electrical undulations like the speech waves, and then had said, not that he could make no use of it, but on the contrary, that by connecting it with the Varley condenser, and by so doing make the Varley condenser speak, wouldn't he have made a useful invention, and one for which he could have obtained a patent? And would his invention have lain simply in the combination of his new apparatus with the Varley condenser? Wouldn't the substance of it have lain in the means for converting the energy of sound waves into the energy of electrical undulations like the sound waves?

We may ask what would have been the result if Mr. Bell had gone into the Patent Office saying he had invented something which was not useful. But that does not meet the case, for he did not go there in that way. He went there telling the world that he had discovered a principle, if you please to call it so, and also that he had devised an apparatus for utilizing that principle or making it efficient, giving to the apparatus a mode of operation not possessed by any prior apparatus, and that it was a useful thing, as the world has since well proved. Now, in that condition of things, taking what Mr. Bell did do, and not what Mr. Browne supposes he might have done, didn't he take a valid patent, and didn't that patent embody a principle which underlies all speaking telephones, so far as we now know? And isn't he entitled, under the law, to protection notwithstanding the fact that so far as the world knows, or has reason to believe, neither Mr. Dolbear, nor any one else, can make a telephone except by embodying in it that which is essential to all telephones, and therefore the substance of the invention?

Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

No. 1628, Equity Docket. | AMERICAN BELL TELEPHONE COMPANY
v.
AMOS E. DOLBEAR ET AL.

BEFORE GRAY AND LOWELL, JJ.

OPINION OF THE COURT.

[JANUARY 24, 1883.]

GRAY, J. Few legal rules have been oftener misunderstood and misapplied than the maxim that you cannot patent a principle. But the confusion on this subject has been so effectually cleared up by the recent judgment of the Supreme Court, delivered by Mr. Justice Bradley, in *Tilghman* v. *Proctor,* 102 U. S. 707, that it will be sufficient for the purposes of this case to state the conclusions there announced.

There can be no patent for a mere principle. The discoverer of a natural force or a scientific fact cannot have a patent for that. But if he invents for the first time a process by which a certain effect of one of the forces of nature is made useful to mankind, and fully describes and claims that process, and also describes a mode or apparatus by which it may be usefully applied, he is, within the meaning, and the very words, of the patent law, "a person who has invented or discovered any new and useful art;" and he is entitled to a patent for the process of which he is the first inventor, and is not restricted to the particular form of mechanism or apparatus by which he carries out that process. Another person, who afterwards invents an improved form of apparatus, embodying the same process, may indeed obtain a patent for his improvement, but he has no right to use the process, in his own or any other form of apparatus, without the consent of the first inventor of the process.

It was decided by this court in *American Bell Telephone Co.* v. *Spencer*, 8 Fed. Rep. 509, and is not denied by the present defendant, that Bell is the first inventor of a speaking telephone. The only controversy is of the extent of his patent.

The draughtsman of the specification has exhibited as clear and accurate a comprehension of the rules of the patent law, as the inventor has of the force of nature with which he was dealing, and of the means by which he reduced that force to a practical use.

The patent is clearly not intended to be limited to a form of apparatus, but embraces a method or process. This is apparent upon the face of the specification.

The inventor begins by saying, "My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line wire."

After describing the advantages of an undulatory current, resulting from gradual changes of intensity, over a pulsatory current caused by sudden changes of intensity, he says: "It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet, a current of electricity is induced in the coils of the latter, and that, when it is made to recede, a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration;" or, as he afterwards repeats in fuller language: "Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; or, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body, that is, to the pitch of sound produced; the intensity of the current varies with the amplitude of the vibration, that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body, that is, to the condensations and rarefactions of air produced by the vibration."

He further says: "There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

"Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence the vibration of the conducting wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibration of the elements of a battery in the liquid in which they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

"In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet, A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch. When the instrument A is placed in a voltaic circuit, *g b e f g*," (in which *b* represents the covered leg of the first electro-magnet; *f* represents the covered leg of another similar electro-magnet, I, whose uncovered leg is marked *h;* and *g* and *e* represent the two points of the voltaic circuit midway of the wire connecting the two magnets) "the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current; but the moment it is set in vibration to produce its musical note, a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f* causes vibration in its armature *h*, when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different."

Then, after showing how two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another, he adds: "I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

"When the armature *c*, Fig. 5, is set in vibration, the armature *h* responds not only in pitch but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds from *h;* and when *c* vibrates forcibly, the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder."

He proceeds to say: "One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

"The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone, the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air-vibrations caused by the sound, that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L."

The reference to figure 7 will be better understood by repeating, slightly amplified, Judge Lowell's explanation in *Spencer's case.* A cone of pasteboard or other suitable material, A, has a membrane, *a*, stretched over its smaller end; at a little distance is the armature *c*, consisting of a piece of iron magnetized by the coil of the electro-magnet *b*, through which is passing a current of electricity. When sounds are made at the mouth of the cone A, the membrane *a* vibrates like the drum of a human ear; and the armature *c*, which is directly in front of the magnet *b*, vibrates with this membrane, and its movements cause pulsations of electricity like those of the air which excited the membrane to pass over the wire *e*, which stretches to another similar magnet, *f*, and cone, L, with its membrane, and its armature, *h*. The second armature and membrane take up the vibrations and make them audible by repeating them into the second cone, L, which translates them into vibrations of the air. In practice, a metallic diaphragm or disc is often substituted for each membrane.

The inventor adds this explanation: "In this specification the three words 'oscillation,' 'vibration' and 'undulation' are used synonymously, and in contradistinction to the terms 'intermittent' and 'pulsatory.' By the term 'body capable of inductive action,' I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action brass, copper and other metals, as well as iron and steel."

His fifth and final claim is of "the method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth."

In this claim, as throughout the specification, the word "method" is evidently used, not as synonymous with "mode" or "apparatus," but as equivalent to "process;" just as it was used by Chief Justice Taney, delivering the judgment of the majority of the court, in *Morse* v. *O'Reilly*, 15 How. 62, 117, as well as by Mr. Justice Grier (who dissented in *Morse* v. *O'Reilly*) in delivering the unanimous judgment in *Corning* v. *Burden*, 15 How. 252, 267. And the invention claimed is not merely the apparatus described, but also the general process or method, by which the wind, or a musical instrument, or the human voice, produces in a current of electricity a succession of electrical disturbances, not sudden and intermittent or pulsatory, but gradual, oscillatory, vibratory or undulatory, so as to give out at the farther end of the conducting wire sounds exactly corresponding in loudness, in pitch, and in tone, character or quality, to the sounds committed to it at the nearer end.

The opinion in *Spencer's case* clearly points out that "Bell discovered a new art—that of transmitting speech by electricity—and has a right to hold the broadest claim for it which can be permitted in any case," and "the invention is nothing less than the transfer to a wire of electrical vibrations like those which a sound has produced in the air;" and that his patent, while not covering the abstract principle, without regard to means, of transmitting speech by electricity, yet is not limited to a particular form of apparatus, but includes the process or method, (using the two words as equivalent,) the essential elements of which are "the production of what the patent calls undulatory vibrations of electricity to correspond with those of the air, and transmitting them to a receiving instrument capable of echoing them."

The evidence in this case clearly shows that Bell discovered that articulate sounds could be transmitted by undulatory vibrations of electricity, and invented the art or process of transmitting such sounds by means of such vibrations. If that art or process is (as the witnesses called by the defendants say it is) the only way by which speech can be transmitted by electricity, that fact does not lessen the merit of his invention, or the protection which the law will give to it.

The mode or apparatus by which Bell effects his purpose is, by using an electro-magnet in the transmitter, and another electro-magnet in the receiver. But the essence of his invention consists not merely in the form of apparatus which he uses, but in the general process or method of which that apparatus is the embodiment.

Dolbear likewise uses an electro-magnet in the transmitter; and both his method and his apparatus, as is admitted in his own affidavit, are substantially like Bell's, until he comes to the receiver. For the magneto-receiver, Dolbear substitutes a condenser-receiver, consisting of two thin metal diaphragms or discs, of about the size and thickness of those used in an ordinary Bell telephone, separated by a very thin air space, one or both discs connected with the conducting wire, and the speaking disc, if not so connected, otherwise charged with electricity; so that, as the varying currents flow into and out of this condenser, the two discs attract one another more or less strongly, and thereby vibrations are set up which correspond to the vibrations of the original sound.

The main difference on which the defendants rely is, that Bell uses what is called dynamic electricity, producing by its motion an electric current; while Dolbear, in his receiver, uses what is called static electricity, producing, while at rest, electrical attraction. And the learned counsel for the defendants illustrate the distinction thus: "It was known, long before Bell's method, that electricity had two properties, very much as water has two properties, namely, first, pressure or head, or that property which tends to make it flow, and which can exist by itself only in the case of an insulated and charged body, or a reservoir of water; and, secondly, that dynamic property arising from its motion, and which never can exist by itself, but depends upon the quantity in motion and the rate of motion. This is not an absolutely exact way of expressing it, for the reason that electricity is not a fluid; but, were it a fluid, the statement would be entirely exact."

It does not appear to us to be important to determine whether, in scientific exactness, the varying influences of static electricity may properly be called currents; or whether the two properties of electricity differ in kind and in substance, or only in degree, or in the form of manifestation and application; or whether the force of the property which tends to make a fluid, when stationary, change its place and flow, is different in kind from that which it exerts, when changing its place and flowing—in short, whether the power of the pressure of water in a reservoir is different in kind from water power in a stream or current.

Whatever name be given to the property, or the manifestation, of the electricity in the defendants' receiver, the facts remain that they avail themselves of Bell's discovery that undulatory vibrations of electricity can intelligibly and accurately transmit articulate speech, as well as of the process which Bell invented, and by which he reduced his discovery to practical use; that they also copy the mode and apparatus by which he creates and transmits the undulatory electrical vibrations, corresponding to those of the air; and that in the plate charged with electricity, which they have substituted for the magnetic coil in the receiver, the charge constantly varies in accordance with the principle which Bell discovered, and by means of the undulatory current caused by the process and in the mode which he invented and patented.

The defendants have therefore infringed Bell's patent by using his general process or method, and should be restrained by injunction from continuing to do so; and it is unnecessary, for the purposes of this decision, to consider whether the defendants' apparatus is a substantial equivalent of the plaintiff's, or whether it is an improvement for which Dolbear might himself be entitled to a patent.

Temporary injunction ordered.

PRELIMINARY INJUNCTION.

UNITED STATES OF AMERICA,
[SEAL] MASSACHUSETTS DISTRICT, SS.

THE PRESIDENT OF THE UNITED STATES OF AMERICA,

To Amos E. Dolbear of Somerville, and Francis M. Holmes of Boston, both in the State of Massachusetts, and Henry B. Metcalf of Pawtucket, in the State of Rhode Island, your agents and servants, GREETING:

Whereas, The American Bell Telephone Company has exhibited its bill of complaint before the Justices of our Circuit Court of the United States for the First Circuit, begun and holden at Boston, within and for the District of Massachusetts, on the sixteenth day of October, A. D. 1882, against you, the said Dolbear, Holmes and Metcalf, praying to be relieved touching the matters therein complained of; and whereas, by an order from said Court, made on the twenty-fourth day of January, A. D. 1883, it was ordered that a writ of injunction issue under the seal of the said Court to restrain you and each and every of you from doing all the matters and things, from the doing of which you are prayed to be restrained in said bill, according in full with the prayer of said bill.

We therefore, in consideration thereof, enjoin and command you, each and every of you, that from and immediately after the receipt and notice of this our writ by you, or any of you, you shall not make, use or sell the improvements described and claimed in two several Letters Patent of the United States, granted to Alexander Graham Bell, one dated March 7, 1876, and numbered 174,465, for an improvement in telegraphy, and the other dated Jan. 30, 1877, and numbered 186,787, for an improvement in electric telegraphy, or any part thereof, or any instrument or apparatus embodying the said improvements or any part thereof, until the further order of Court.

Whereof you are not to fail on pain of ten thousand dollars, to be levied on your and each of your goods, chattels, lands and tenements to our use.

Witness the Honorable Morrison R. Waite, at Boston, this twenty-fourth day of January, in the year of our Lord one thousand eight hundred and eighty-three.

JOHN G. STETSON, *Clerk.*

A true copy.

Attest:

[SEAL] JOHN G. STETSON, *Clerk.*